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Comparative analysis of sleep duration and stroke prevalence in China and the U.S. before and during COVID-19

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Abstract

Background This study compares sleep duration and stroke risk between residents of China and the U.S. during and outside the COVID-19 pandemic, examining age as an interaction effect.

Methods This study analyzed data from the National Health and Nutrition Examination Survey (NHANES) and the China Health and Retirement Longitudinal Study (CHARLS). A total of 9131 American adults participated from 2017 to March 2020, and 7678 from August 2021 to August 2023. In China, 13,514 adults participated in 2018 and 9441 in 2020. Stroke incidence was assessed via survey responses, with "yes" indicating a history of stroke. Participants were categorized by age, and multivariable logistic regression and interaction analyses evaluated age effects, supported by subgroup and sensitivity analyses. Restricted cubic splines (RCS) examined nonlinear associations between sleep duration and stroke risk, while mediation analyses investigated the roles of hypertension, diabetes, and lipid abnormalities.

Results The study found that during the pandemic, in the multivariable-adjusted model, there was a "U-shaped" association between sleep duration and the prevalence of stroke (China: *P for trend* = 0.009, *P non-linear* = 0.0004; the United States: *P for trend* = 0.012, *P non-linear* = 0.0004). Similarly, in the multivariable-adjusted model, during the COVID-19 pandemic, compared with the non-pandemic period, long sleep duration (≥ 9 h) was potentially a risk factor for the prevalence of stroke among American adults (for those under 60 years old: odds ratio (*OR*) 95% confidence interval (CI)[1.836(1.138, 2.962)], *P* = 0.013; for those 60 years old and above: *OR* 95%CI[1.44(1.15, 1.436)], *P* = 0.044). In contrast, in China, compared with the pandemic period, the association between long sleep duration (≥ 9 h) and the prevalence of stroke was stronger during the non—pandemic period (for those 60 years old and above: *OR* 95%CI[1.342(1.132, 1.59)], *P* = 0.001), but no association was found among those under 60 years old. Mediation analysis indicated that in China, lipid abnormalities partially influenced the association between long sleep duration (≥ 9 h) and the prevalence of stroke. The mediation proportion was 8.39% in the overall population, and as high as 20.25% among the elderly aged 60 years and above.

Conclusion During the COVID-19 pandemic, the association between prolonged sleep duration (≥ 9 h) and stroke risk among U.S. adults aged under 60 significantly increased, although this trend was less pronounced in China. These

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findings suggest that public health interventions should account for the varying impact of sleep duration across different populations.

Keywords Sleep duration, Age, Stroke, Lipid abnormalities, Epidemic

Introduction

According to the 2021 Global Burden of Disease Study, stroke has become the third leading cause of death worldwide, following ischemic heart disease and COVID-19 [1]. The occurrence of stroke results from a complex interplay of multiple factors, and traditional risk factors such as diabetes, unhealthy dietary habits, smoking, and physical inactivity do not fully account for all stroke risk. Observational studies have indicated that a sleep duration outside the normal range is associated with major cardiovascular disease risk factors, including hypertension, obesity, diabetes, and dyslipidemia, which may indirectly increase the risk of stroke [2–5]. Despite several prospective studies exploring the relationship between sleep duration and stroke risk, the findings remain inconsistent. Some studies indicate a nonlinear relationship where both short and long sleep durations are associated with an increased risk of stroke, whereas others report higher stroke incidence only among those with either short or long sleep durations, and some even fail to find a significant association between the two. Furthermore, varying sleep durations may be closely related to specific types of stroke [6–10] This complexity underscores the necessity for further research to elucidate the heterogeneity of stroke risk associated with sleep and to deepen our understanding of the role of sleep in the pathogenesis of stroke.

The COVID-19 pandemic has significantly impacted individuals' lifestyles and daily routines, severely disrupting many people's sleep patterns, including sleep disorders, sleep deprivation, sleep duration, sleep quality, and circadian rhythms [11]. Research indicates a significant increase in reports of difficulty falling asleep, frequent awakenings during the night and early morning, and nightmares among young people in Canada [12].Sleep disorders resulting from SARS-CoV-2 infection, such as sleep deprivation, circadian rhythm disruption, and fibromyalgia, have become prominent features of long-term COVID-19 symptoms [13]. Furthermore, stroke has been identified as a potential complication of COVID-19, with patients worldwide presenting with both conditions [14]. Although this perspective remains contentious, the majority of studies have confirmed a relationship between the mechanisms of stroke occurrence and COVID-19 [15].In particular, the concept that the SARS-CoV-2 virus induces a hypercoagulable state and tissue damage by binding to angiotensin-converting enzyme 2 (ACE2) receptors on brain and vascular cells has been widely recognized in research [16]. These findings underscore the impact of COVID-19 on sleep patterns and its potential role as a complication of stroke.

This study evaluated the impact of sleep duration on stroke risk during the COVID-19 pandemic, covering a wide range of regions and adhering to rigorous protocols. This contributes to the identification of stroke risk factors, providing a basis for prevention and intervention strategies aimed at improving patient health and quality of life.

Materials and methods

Data sources and study population

This study utilizes the China Health and Retirement Longitudinal Study (CHARLS) and the National Health and Nutrition Examination Survey (NHANES) from the United States, two large national datasets, to analyze the relationship between sleep duration and stroke risk during the COVID-19 pandemic [17]. The 2020 CHARLS dataset, released on November 16, 2023, captures information related to the COVID-19 pandemic. Our primary focus is on utilizing datasets from the COVID-19 pandemic period and conducting comparative analyses with data from 2018 [18]. The U.S. data integrate NHANES cycles from the pre-pandemic period of 2017-March 2020 and the pandemic period from August 2021-August 2023.

The study uses two national datasets: CHARLS and NHANES, which provide comprehensive data on demographics, health status, medication use, and lab tests, enabling weighted results for nationally representative estimates. The NHANES dataset has received ethical approval from the National Center for Health Statistics (NCHS) Institutional Review Board (IRB) in the United States (https://www.cdc.gov/nchs/nhanes/index.htm). Similarly, the CHARLS dataset was approved by the Ethics Committee of Peking University (IRB00001052–11014), and informed consent was obtained from the participants. The participant selection process for the study is illustrated in Fig. 1.

Definition of stroke

According to established precedents, the CHARLS database determines the incidence of stroke on the basis of self-reports, where individuals confirm that they have

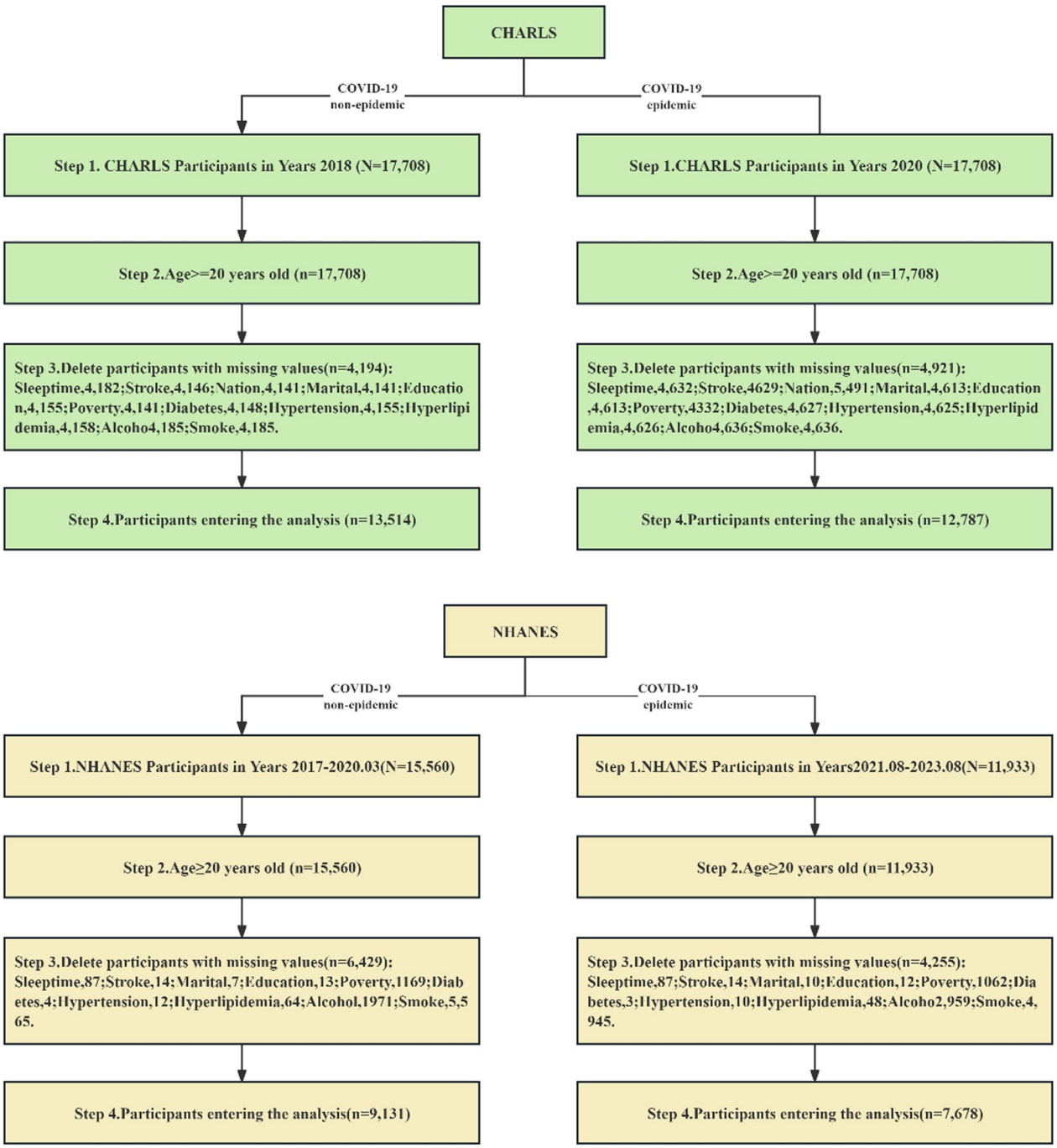

Fig. 1 Flow chart of participants in the CHARLS and NHANES databases. A flow chart of the CHARLS [**A** 2018 and 2020 survey data] and NHANES [**B** 2017–2020.03 and 2021.08–2023.08, Year cycle]. The strategy employed involved extracting the variables, calculating the required indicators directly, and subsequently eliminating the missing values

received a stroke diagnosis from a physician [6, 19]. The date of stroke diagnosis was recorded as falling between the date of the most recent interview and the date of the interview in which the stroke event was reported. In the NHANES database, the definition of stroke is based on self-reported prior diagnoses made by a physician during face-to-face interviews. Individuals who answer "yes" to the following question are considered to have had a stroke: "Have you ever been told by a doctor or health professional that you had a stroke?" Both the CHARLS

Table 1 Sociodemographic characteristics of Chinese adults with stroke according to the CHARLS survey cycle

Characteristic	2018 CHARLS Database				2020 CHARLS Database			
	Total (n = 13,514)	Non-stroke (n = 12,367)	Stroke (n = 1147)	*P*	Total (n = 9,441)	Non-stroke (n = 8615)	Stroke (n = 826)	*P*
Sleeptime	6.16 ± 2.08	6.17 ± 2.04	6.03 ± 2.43	0.047	6.02 ± 2.00	6.04 ± 1.97	5.79 ± 2.26	0.002
Age	64.73 ± 9.22	64.43 ± 9.20	67.86 ± 8.86	< 0.001	66.30 ± 8.76	66.06 ± 8.74	68.79 ± 8.53	< 0.001
Sex. n(%)				0.025				0.015
Female	7226 (53.47)	6649 (53.76)	577 (50.31)		5056 (53.55)	4633 (53.78)	423 (51.21)	
Male	6288 (46.53)	5718 (46.24)	570 (49.69)		4385 (46.45)	3982 (46.22)	403 (48.79)	
Marital status,n(%)				< 0.001				0.002
Nonmarried,n(%)	2338 (17.30)	2075 (16.78)	263 (22.93)		1732 (18.35)	1547 (17.96)	185 (22.40)	
Married	11,176 (82.70)	10,292 (83.22)	884 (77.07)		7709 (81.65)	7068 (82.04)	641 (77.60)	
Ethnicity,n(%)				0.013				0.559
non-Han ethnicity	1044 (7.73)	934 (7.55)	110 (9.59)		684 (7.24)	620 (7.20)	64 (7.75)	
Han ethnicity	12,470 (92.27)	11,433 (92.45)	1037 (90.41)		8757 (92.76)	7995 (92.80)	762 (92.25)	
Education,n(%)				0.072				0.028
Primary school or below	9017 (66.72)	8218 (66.45)	799 (69.66)		6680 (70.76)	6065 (70.40)	615 (74.46)	
Middle school	2877 (21.29)	2660 (21.51)	217 (18.92)		1890 (20.02)	1753 (20.35)	137 (16.59)	
high school or abover	1620 (11.99)	1489 (12.04)	131 (11.42)		871 (9.23)	797 (9.25)	74 (8.96)	
Hypertension,n(%)				< 0.001				< 0.001
No	7793 (57.67)	7469 (60.39)	324 (28.25)		5217 (55.26)	4988 (57.90)	229 (27.72)	
Yes	5721 (42.33)	4898 (39.61)	823 (71.75)		4224 (44.74)	3627 (42.10)	597 (72.28)	
Diabetes,n(%)				< 0.001				< 0.001
No	11,648 (86.19)	10,794 (87.28)	854 (74.46)		7942 (84.12)	7341 (85.21)	601 (72.76)	
Yes	1866 (13.81)	1573 (12.72)	293 (25.54)		1499 (15.88)	1274 (14.79)	225 (27.24)	
Dyslipidemia,n(%)				< 0.001				< 0.001
No	10,358 (76.65)	9717 (78.57)	641 (55.88)		6798 (72.01)	6388 (74.15)	410 (49.64)	
Yes	3156 (23.35)	2650 (21.43)	506 (44.12)		2643 (27.99)	2227 (25.85)	416 (50.36)	
Drinking,n(%)				< 0.001				< 0.001
No	9218 (68.23)	8341 (67.46)	877 (76.46)		6345 (67.21)	5719 (66.38)	626 (75.79)	
Yes	4293 (31.77)	4023 (32.54)	270 (23.54)		3096 (32.79)	2896 (33.62)	200 (24.21)	
Smoking,n(%)				< 0.001				< 0.001
No	10,004 (74.04)	9096 (73.57)	908 (79.16)		7086 (75.06)	6426 (74.59)	660 (79.90)	
Yes	3507 (25.96)	3268 (26.43)	239 (20.84)		2355 (24.94)	2189 (25.41)	166 (20.10)	
Poverty level,n(%)				0.006				0.011
Low	2224 (25.01)	1990 (24.57)	234 (29.47)		2378 (25.19)	2139 (24.83)	239 (28.93)	
Middle	4446 (49.99)	4083 (50.41)	363 (45.72)		4670 (49.47)	4265 (49.51)	405 (49.03)	
High	2224 (25.01)	2027 (25.02)	197 (24.81)		2393 (25.35)	2211 (25.66)	182 (22.03)	

and NHANES databases determine the incidence of stroke using self-reported data. CHARLS conducts spot checks on medical records, while NHANES uses the Computer Assisted Personal Interviewing (CAPI) system for surveys, reviews the data, and audits the recorded interviews to reduce false positives and false negatives.

Assessment of sleep duration and other covariates

Sleep duration data were sourced from two databases, CHARLS and NHANES, through self-reporting. In the CHARLS database survey, respondents were asked at their homes, "How many hours do you approximately actually sleep every night on average within the past month?" For the NHANES database, the same CAPI-equipped trained interviewers inquired, "How much sleep do you usually get at night on weekdays or workdays?" The response categories of this question were "Yes," "No," "Refused," and "Do not know." For participants whose response was "Do not know" or "Refused," their data were considered as a missing value. The recorded data were classified into three groups: short (less than 7 h per night), normal (7–9 h per night), and

Table 2 Sociodemographic characteristics of US adults with stroke by NHANES survey cycle

Characteristic	2017–2020.03 NHANES Database				2021.08–2023.08 NHANES Database			
	Total (n = 9,131)	Non-stroke (n = 8656)	Stroke (n = 475)	*P*	Total (n = 7,678)	Non-stroke (n = 7318)	Stroke (n = 360)	*P*
Sleeptime	7.59 ± 1.68	7.58 ± 1.65	7.83 ± 2.20	0.014	7.72 ± 1.61	7.69 ± 1.57	8.23 ± 2.13	< 0.001
Age	51.07 ± 17.69	50.27 ± 17.57	65.61 ± 12.84	< 0.001	53.51 ± 17.54	52.85 ± 17.52	66.94 ± 11.33	< 0.001
Sex,n(%)				0.521				0.159
Female	4706 (51.54)	4468 (51.62)	238 (50.11)		5056 (53.55)	3266 (56.31)	1406 (49.44)	
Male	4425 (48.46)	4188 (48.38)	237 (49.89)		4385 (46.45)	2534 (43.69)	1438 (50.56)	
Marital status,n(%)				< 0.001				< 0.001
Non-married	1772 (19.42)	1727 (19.97)	45 (9.47)		1604 (20.92)	1565 (21.41)	39 (10.86)	
Married	7352 (80.58)	6922 (80.03)	430 (90.53)		6064 (79.08)	5744 (78.59)	320 (89.14)	
Race,n(%)				< 0.001				0.158
Mexcian American	1053 (11.53)	1027 (11.86)	26 (5.47)		538 (7.01)	522 (7.13)	16 (4.44)	
other Hispanic	928 (10.16)	892 (10.30)	36 (7.58)		762 (9.92)	725 (9.91)	37 (10.28)	
Non-Hispanic White	3178 (34.80)	2976 (34.38)	202 (42.53)		4491 (58.49)	4284 (58.54)	207 (57.50)	
Non-Hispanic Black	2425 (26.56)	2263 (26.14)	162 (34.11)		974 (12.69)	917 (12.53)	57 (15.83)	
Other Race	1547 (16.94)	1498 (17.31)	49 (10.32)		913 (11.89)	870 (11.89)	43 (11.94)	
Education,n(%)				< 0.001				< 0.001
Under high school	1730 (18.97)	1610 (18.63)	120 (25.26)		1011 (13.19)	915 (12.52)	96 (26.67)	
High school	2194 (24.06)	2040 (23.60)	154 (32.42)		1711 (22.32)	1613 (22.08)	98 (27.22)	
Above high school	5194 (56.96)	4993 (57.77)	201 (42.32)		4944 (64.49)	4778 (65.40)	166 (46.11)	
Hypertension,n(%)				< 0.001				< 0.001
No	5612 (61.54)	5498 (63.60)	114 (24.00)		4782 (62.36)	4678 (64.00)	104 (28.97)	
Yes	3507 (38.46)	3146 (36.40)	361 (76.00)		2886 (37.64)	2631 (36.00)	255 (71.03)	
Diabetes,n(%)				< 0.001				< 0.001
No	4686 (51.34)	4529 (52.35)	157 (33.05)		4587 (59.77)	4449 (60.81)	138 (38.44)	
Yes	4441 (48.66)	4123 (47.65)	318 (66.95)		3088 (40.23)	2867 (39.19)	221 (61.56)	
Dyslipidemia,n(%)				< 0.001				< 0.001
No	5848 (64.50)	5672 (65.98)	176 (37.45)		4627 (60.64)	4514 (62.07)	113 (31.56)	
Yes	3219 (35.50)	2925 (34.02)	294 (62.55)		3003 (39.36)	2758 (37.93)	245 (68.44)	
Drinking,n(%)				< 0.001				< 0.001
No	1590 (22.21)	1457 (21.44)	133 (36.54)		810 (17.16)	759 (16.73)	51 (27.87)	
Yes	5570 (77.79)	5339 (78.56)	231 (63.46)		3909 (82.84)	3777 (83.27)	132 (72.13)	
Smoking,n(%)				0.253				0.08
No	2165 (60.71)	1996 (60.45)	169 (64.02)		2019 (73.87)	1873 (73.48)	146 (79.35)	
Yes	1401 (39.29)	1306 (39.55)	95 (35.98)		714 (26.13)	676 (26.52)	38 (20.65)	
Poverty level,n(%)				< 0.001				< 0.001
Low	2504 (31.45)	2339 (31.01)	165 (39.29)		1621 (24.50)	1515 (24.06)	106 (33.33)	
Middle	1223 (15.36)	1154 (15.30)	69 (16.43)		929 (14.04)	869 (13.80)	60 (18.87)	
High	4235 (53.19)	4049 (53.69)	186 (44.29)		4066 (61.46)	3914 (62.15)	152 (47.80)	

long (more than 9 h per night) [20]. Demographic information was collected through a questionnaire, including age, sex, race/ethnicity (CHARLS: Han ethnicity, non-Han ethnicity; NHANES: Mexican American, other Hispanic, non-Hispanic White, non-Hispanic Black, other race), marital status (married, unmarried), education level (CHARLS: primary or below, secondary, tertiary or higher; NHANES: below high school, high school, above high school), and household income poverty level as classified into low, medium, and high categories on the basis of the NHANES monthly poverty index (≤ 1.30, 1.30–1.85, > 1.85). CHARLS categorizes per capita household income poverty level on the basis of total income divided by family size (low, medium, high). Current smoking status (smoker, nonsmoker) and current drinking status (drinker, nondrinker) were also recorded. The diagnosis

Table 3 Association of covariates and stroke risk in two CHARLS databases

Characteristic	2018 CHARLS Database		2020 CHARLS Database	
	*OR*_95CI%	*P value*	*OR*_95CI%	*P value*
Sex				
Female	1(Ref)		1(Ref)	
Male	1.01 (0.88, 1.17)	0.8423	1.0 (0.8, 1.2)	0.762
Age				
< 60	1(Ref)		1(Ref)	
≥ 60	2.17 (1.82, 2.59)	< 0.0001	2.2 (1.7, 3.0)	< 0.001
Ethnicity				
non-Han ethnicity	1(Ref)		1(Ref)	
Han ethnicity	0.83 (0.64, 1.07)	0.1484	1.2 (0.7, 2.0)	0.433
Education				
Primary school or below	1(Ref)		1(Ref)	
Middle school	0.85 (0.70, 1.04)	0.1168	0.8 (0.6, 1.1)	0.103
High school or above	0.97 (0.77, 1.23)	0.805	0.6 (0.4, 0.9)	0.013
Marital status				
Nonmarried	1(Ref)		1(Ref)	
Married	0.69 (0.58, 0.82)	< 0.0001	0.8 (0.6, 1.0)	0.035
Poverty level				
Low	1(Ref)		1(Ref)	
Middle	0.81 (0.66, 0.99)	0.0432	1.0 (0.8, 1.4)	0.77
High	0.80 (0.63, 1.01)	0.0627	0.7 (0.5, 1.0)	0.075
Hypertension				
No	1(Ref)		1(Ref)	
Yes	3.74 (3.19, 4.38)	< 0.0001	3.0 (2.4, 3.8)	< 0.001
Diabetes				
No	1(Ref)		1(Ref)	
Yes	2.19 (1.85, 2.60)	< 0.0001	2.1 (1.6, 2.7)	< 0.001
Dyslipidemia				
No	1(Ref)		1(Ref)	
Yes	2.98 (2.57, 3.45)	< 0.0001	2.5 (2.0, 3.1)	< 0.001
Drinking				
No	1(Ref)		1(Ref)	
Yes	0.62 (0.53, 0.74)	< 0.0001	0.6 (0.5, 0.8)	< 0.001
Smoking				
No	1(Ref)		1(Ref)	
Yes	0.64 (0.53, 0.76)	< 0.0001	0.7 (0.5, 0.9)	0.008
Sleeptime, hours				
≤ 7	1(Ref)		1(Ref)	
7–9	0.73 (0.60, 0.88)	0.001	0.8 (0.7, 0.9)	0.0491
> 9	1.70 (1.31, 2.21)	< 0.0001	1.8 (1.2, 2.8)	0.007

Table 4 Association of covariates and stroke risk in two NHANES databases

Characteristic	2017–2020.03 NHANES Database		2021.08–2023.08 NHANES Database	
	*OR*_95CI%	*P value*	*OR*_95CI%	*P value*
Sex				
Female	1(Ref)		1(Ref)	
Male	1.1 (0.9, 1.3)	0.521	1.2 (0.9, 1.4)	0.159
Age				
< 60	1(Ref)		1(Ref)	
≥ 60	4.6 (3.8, 5.7)	**< 0.001**	4.6(3.5,5.9)	**< 0.001**
Race				
Mexcian American	1(Ref)		1(Ref)	
other Hispanic	1.6 (1.0, 2.7)	0.074	1.7 (0.9, 3.0)	0.094
Non-Hispanic White	2.7 (1.8, 4.1)	**< 0.001**	1.6 (0.9, 2.6)	0.084
Non-Hispanic Black	2.8 (1.9, 4.3)	**< 0.001**	2.0 (1.2, 3.6)	**0.014**
Other Race	1.3 (0.8, 2.1)	0.298	1.6 (0.9, 2.9)	0.109
Education				
Under high school	1(Ref)		1(Ref)	
High school	1.0 (0.8, 1.3)	0.92	0.6 (0.4, 0.8)	**< 0.001**
Above high school	0.5 (0.4, 0.7)	**< 0.001**	0.3 (0.3, 0.4)	**< 0.001**
Marital status				
Nonmarried	1(Ref)		1(Ref)	
Married	2.4 (1.7, 3.3)	**< 0.001**	2.2 (1.6, 3.1)	**< 0.001**
Poverty level				
Low	1(Ref)		1(Ref)	
Middle	0.8 (0.6, 1.1)	0.263	1.0 (0.7, 1.4)	0.937
High	0.7 (0.5, 0.8)	**< 0.001**	0.6 (0.4, 0.7)	**< 0.001**
Hypertension				
No	1(Ref)		1(Ref)	
Yes	5.5 (4.5, 6.9)	**< 0.001**	4.4 (3.5, 5.5)	**< 0.001**
Diabetes				
No	1(Ref)		1(Ref)	
Yes	2.2 (1.8, 2.7)	**< 0.001**	2.5 (2.0, 3.1)	**< 0.001**
Dyslipidemia				
No	1(Ref)		1(Ref)	
Yes	3.2 (2.7, 3.9)	**< 0.001**	3.5 (2.8, 4.5)	**< 0.001**
Drinking				
No	1(Ref)		1(Ref)	
Yes	0.5 (0.4, 0.6)	**< 0.001**	0.5 (0.4, 0.7)	**< 0.001**
Smoking				
No	1(Ref)		1(Ref)	
Yes	0.9 (0.7, 1.1)	0.254	0.7 (0.5, 1.0)	0.081
Sleeptime, hours				
≤ 7	1(Ref)		1(Ref)	
7–9	0.8 (0.6, 1.0)	**0.045**	0.7 (0.6, 1.0)	**0.039**
> 9	1.6 (1.3, 2.0)	**< 0.001**	2.0 (1.6, 2.6)	**< 0.001**

The bold values denote statistically significant results at the predefined threshold ($P < 0.05$)

of diabetes comprises the following components, any of which can result in a diagnosis of diabetes: (1) the individual has been diagnosed with diabetes by a physician; (2) the glycated hemoglobin (HbA1c) level is > 6.5%; and (3) the individual is currently using antidiabetic medications or insulin. The following criteria may be used to diagnose dyslipidemia: hypertriglyceridemia (TG ≥ 150 mg/

Table 5 Weighted odds ratios (95% confidence intervals) of stroke and different durations in different models for both the CHARLS and NHANES databases

Variables	Model1		Model2		Model3		Model4	
	OR (95%CI)	*P value*	OR (95%CI)	*P value*	OR (95%CI)	*P value*	OR (95%CI)	*P value*
Sleeptime_2018								
< 7 h	1(Ref)		1(Ref)		1(Ref)		1(Ref)	
7–9 h	0.78 (0.67,0.92)	0.004	0.81 (0.69,0.96)	0.015	0.79 (0.65,0.97)	0.022	0.81 (0.67,0.99)	**0.044**
> 9 h	1.26 (1.01,1.58)	0.049	1.10 (0.87,1.39)	0.411	1.08 (0.82,1.43)	0.587	1.10 (0.83,1.47)	0.496
P-trend	**< 0.001**		**0.027**		**0.024**		0.120	
Sleeptime_2020								
< 7 h	1(Ref)		1(Ref)		1(Ref)		1(Ref)	
7–9 h	0.70 (0.53,0.91)	0.007	0.72 (0.55,0.96)	0.024	0.74 (0.56,0.98)	0.037	0.75 (0.56,0.99)	**0.042**
> 9 h	1.32 (0.92,1.90)	0.126	1.16 (0.79,1.70)	0.437	1.14 (0.78,1.67)	0.503	1.17 (0.79,1.71)	0.435
P-trend	**< 0.001**		**0.004**		**0.004**		**0.009**	
Sleeptime_2017-2020.03								
< 7 h	1(Ref)		1(Ref)		1(Ref)		1(Ref)	
7–9 h	0.79 (0.63,0.99)	0.045	0.74 (0.58,0.94)	0.013	0.75 (0.58,0.97)	0.026	0.77 (0.56,0.98)	**0.040**
> 9 h	1.63 (1.31,2.03)	< 0.001	1.28 (1.02,1.61)	0.033	1.13 (0.89,1.44)	0.32	1.06 (0.74,1.53)	0.736
P-trend	**< 0.001**		**0.028**		**0.036**		0.579	
Sleeptime_2021.08–2023.08								
< 7 h	1(Ref)		1(Ref)		1(Ref)		1(Ref)	
7–9 h	0.75 (0.57,0.99)	**0.039**	0.72 (0.55,0.96)	**0.024**	0.78 (0.58,1.06)	0.11	0.77 (0.57,1.04)	0.091
> 9 h	2.04 (1.59,2.63)	**< 0.001**	1.66 (1.28,2.15)	**< 0.001**	1.57 (1.19,2.09)	**0.002**	1.60 (1.20,2.12)	**0.001**
P-trend	**< 0.001**		**< 0.001**		**< 0.001**		**0.012**	

The bold values denote statistically significant results at the predefined threshold ($P < 0.05$)

Model 1: Crude

Model 2: Adjusted for gender, age, and race

Model 3: Adjusted for gender, age, race, education, marry, poverty

Model 4: Adjusted for gender, age, race, education, marry, poverty, Hypertension, Diabetes, Dyslipidemia, Drinking, Smoking

dL) and/or hypercholesterolemia (total cholesterol (TC) ≥ 240 mg/dL, LDL ≥ 160 mg/dL, HDL < 40 mg/dL). The definition of hypertension includes (1) taking antihypertensive medications; (2) having been informed by a licensed physician or indicated in a questionnaire that they are using antihypertensive prescription drugs; and (3) an average systolic blood pressure (SBP) ≥ 140 mmHg and/or diastolic blood pressure (DBP) ≥ 90 mmHg (averaged over three measurements). Any one of the aforementioned conditions may be sufficient for a diagnosis of hypertension.

Statistical analysis

The data analysis for this study was carried out using R version 4.3.0. This version was chosen because it contains updated statistical analysis packages, which enables more efficient handling of complex data structures and demonstrates better performance when dealing with large-scale datasets. Normally distributed continuous data were expressed as the mean ± SD. Comparisons between groups were performed via independent samples t-tests; categorical data are expressed as n (%) and were analyzed via chi-square tests or Fisher's exact test, and group comparisons were deemed statistically significant at a *P value* < 0.05.A multivariable logistic regression model was used to determine the odds ratio (*OR*) and 95% confidence interval (95% CI) for the relationship between sleep duration and stroke. The results included unadjusted, minimally adjusted (age, sex, race), multivariable adjusted (age, sex, race, marital status, education level, and poverty level), and fully adjusted analyses (all covariates). Frequently used in statistical modeling to depict the non-linear relationship between two variables are restricted cubic spline (RCS) curves. In RCS analysis, the range of the independent variable is divided into multiple intervals (knots). Within each interval, a cubic polynomial function is fitted, and these polynomials are connected through the knots to ensure the overall smoothness of the curve. RCS have the ability to capture complex non-linear patterns, which allows for a more precise evaluation of the association between sleep

Table 6 Interactive effect of age in patients with stroke in two CHARLS databases

Subgroups	Sleeptime, hours	with stroke		*P* for interaction	with stroke		*P* for interaction
		Crude *OR*_95CI%	Crude *P value*		Adjusted *OR*_95CI %	Adjusted *P value*	
Age in 2018 (years)				**< 0.001**			0.561
< 60	< 7	1(Ref)			1(Ref)		
	7–9	0.942(0.508,1.749)	0.851		0.936(0.493,1.775)	0.839	
	> 9	1.392(0.822,2.357)	0.219		1.485(0.767,2.872)	0.241	
P-trend		0.90 (0.816,0.982)	**0.019**		0.892 (0.799,0.996)	**0.044**	
≥ 60	< 7	1(Ref)			1(Ref)		
	7–9	0.694(0.511,0.943)	**0.019**		0.691(0.503,0.95)	**0.023**	
	> 9	1.239(1.06,1.447)	**0.007**		1.342(1.132,1.59)	**0.001**	
P-trend		0.974(0.940,1.011)	0.164		0.979 (0.937.1.024)	0.362	
Age in 2020 (years)				**< 0.001**			0.050
< 60	< 7	1(Ref)			1(Ref)		
	7–9	1.857(0.604,5.709)	0.280		2.401(0.694,8.298)	0.166	
	> 9	0.448(0.087,2.322)	0.339		0.371(0.054,2.537)	0.312	
P-trend		0.851(0.726,0.998)	**0.030**		0.877(0.7327,1.050)	0.152	
≥ 60	< 7	1(Ref)			1(Ref)		
	7–9	1.258(0.763,2.076)	0.368		1.105(0.644,1.896)	0.717	
	> 9	1.186(0.868,1.62)	0.284		1.27(0.894,1.805)	0.182	
P-trend		0.927(0.873,0.984)	**0.012**		0.931(0.868,0.999)	**0.046**	

The bold values denote statistically significant results at the predefined threshold ($P < 0.05$)

duration and the prevalence of stroke. We also investigated the relationship between participants' sleep duration and stroke risk separately based on the significant interaction variable of age using this multivariable logistic regression model. Sensitivity analyses involved the exclusion of outliers, defined as sleep duration values exceeding the mean by 2 standard deviations. Likelihood ratio tests were employed to assess subgroup interactions. Furthermore, restricted cubic spline analysis was used to explore the relationship between sleep duration and stroke risk. In this study, the mediation analysis was carried out using the mediation package in R software. Through this analysis, we can calculate the magnitude of the mediating effect required. This serves as an ideal strategy for clarifying the action pathways and providing statistical evidence for the mechanism analysis. The direct effect represents the association between sleep duration and stroke risk, while the indirect effect, mediated by hypertension, hyperglycemia, and hyperlipidemia, also shows the link between them. The proportion mediated indicates the percentage of the mediating effect. *P* value < 0.05 indicated a significant difference.

Results

Results from CHARLS data analysis

Baseline characteristics of the participants

There were 13,514 participants in the 2018 CHARLS study (mean age 64.73 ± 9.22 years; male: female ratio was 49.69%:50.31%), with 1147 stroke participants and 12,367 non-stroke participants. There were 9441 participants in the 2020 CHARLS study (mean age 66.30 ± 8.76 years; male: female ratio was 48.79%:51.21%), with 826 stroke participants and 8615 non-stroke participants. In the pre-pandemic and pandemic phases of COVID-19, the stroke group had a significantly higher proportion in age distribution, poverty levels, prevalence of diabetes, hypertension, and dyslipidemia than the non-stroke group. In terms of sex composition, the *P-values* are 0.025 and 0.015, respectively. For age, poverty levels, diabetes, hypertension, and dyslipidemia, the *P-values* were all less than 0.001. The stroke group also had a significantly different average sleep duration ($P = 0.047$ vs. $P = 0.002$), proportion of married individuals ($P < 0.001$ vs. $P = 0.002$), and current smoking and drinking status ($P < 0.01$ vs. $P < 0.01$). When comparing different sleep-duration groups (< 7 h, 7–9 h, > 9 h) before and during the pandemic, the stroke risk significantly decreased in all groups during the pandemic. Pre-pandemic stroke risks were 6.38% (< 7 h), 5.08% (7–9 h), and 7.9% (> 9 h),

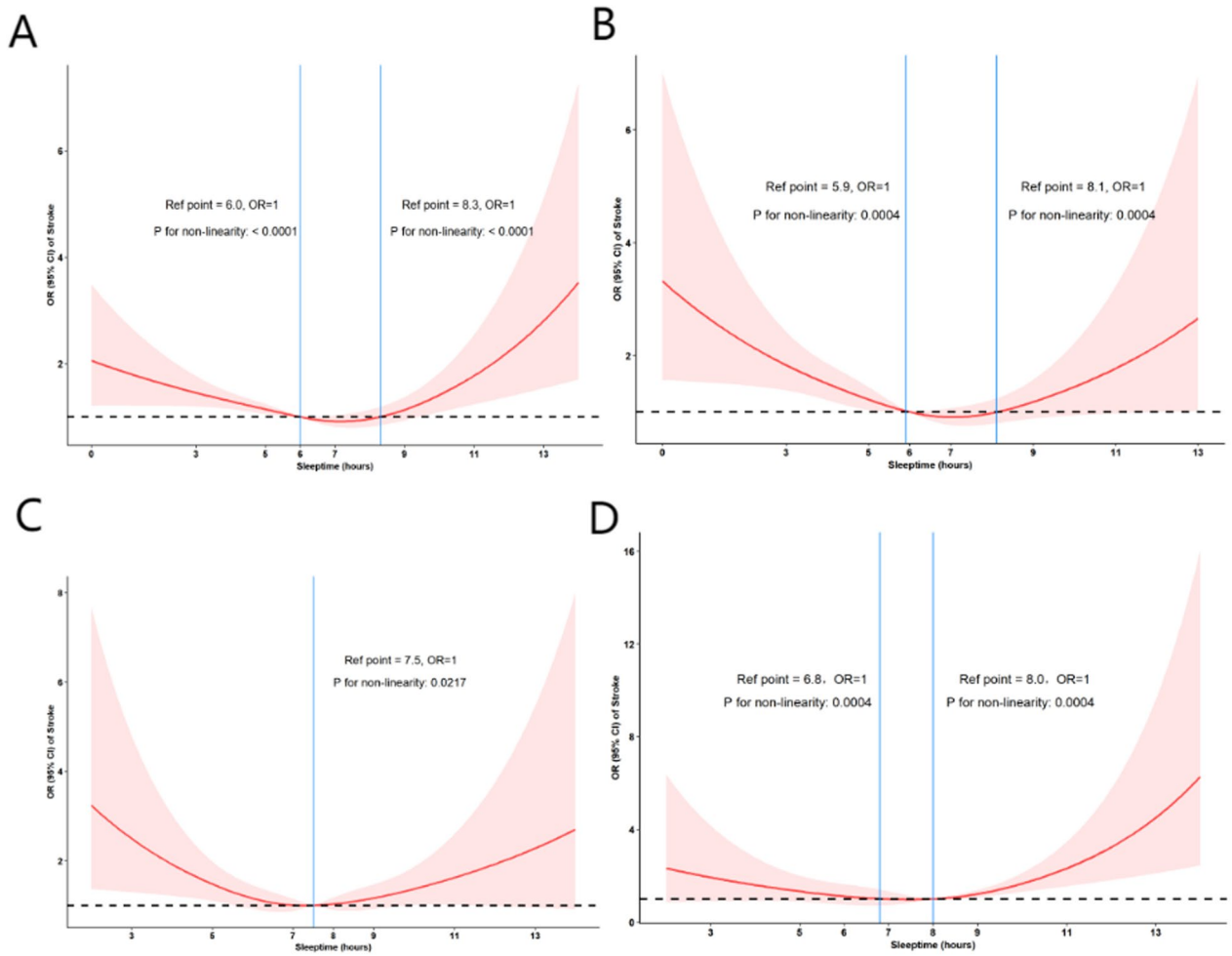

Fig. 2 Dose–response relationships between sleep duartion and stroke risk in CHARLS, separately (**A**), 2018 database (**B**), 2020database. *OR*(95%CI) (shaded areas)were adjusted for gender, age, race, education, marry, poverty, hypertension, diabetes, dyslipidemia, drinkl, smoken. Vertical blue solid lines indicate the minimal threshold for the beneficial association with estimated *OR* = 1

dropping to 2.93%, 2.06%, and 3.84% respectively during the pandemic (Tables 1, 2).

Multivariate logistic regression analysis of sleep duration and stroke incidence

In the 2018 data, using a < 7-h sleep duration as a reference, for those sleeping 7–9 h, odds ratios in different models were: Model 1 (*OR*(95%CI) = 0.78 (0.67,0.92), *P* = 0.004), Model 2 (*OR*(95%CI) = 0.81 (0.69,0.96), *P* = 0.015), Model 3 (*OR*(95%CI) = 0.79 (0.65,0.97), *P* = 0.022), Model 4 (*OR*(95%CI) = 0.81 (0.67,0.99), *P* = 0.044), indicating a protective effect against stroke. For a sleep duration of more than 9 h in the 2018 database, the unadjusted OR was 1.26 (*OR*(95%CI) = 1.26(1.01–1.58), *P* = 0.049), and after adjustment, it became *OR*(95%CI): 1.10 (0.83–1.47), *P* = 0.496. In 2008, for Model 1, a significant positive correlation between increased sleep duration and related variables was indicated (*P-trend* < 0.001). Similarly, for Model 2 (*P-trend* = 0.027) and Model 3 (*P-trend* = 0.024), significant positive correlations were demonstrated. However, in contrast, for Model 4, no significant trend was suggested (*P-trend* = 0.120) (Tables 3, 4, 5).

In the 2020 data, a 7–9-h sleep duration was also identified as a protective factor: Model 1 (*OR*(95%CI) = 0.70 (0.53,0.91), *P* = 0.007), Model 2 (*OR*(95%CI) = 0.72 (0.55,0.96), *P* = 0.024), Model 3 (*OR*(95%CI) = 0.74 (0.56,0.98), *P* = 0.037), Model 4 (*OR*(95%CI) = 0.75 (0.56,0.99), *P* = 0.042). By 2020, all models indicated significance. In Model 1, a significant result was shown (*P-trend* < 0.001). For Model 2 (*P-trend* = 0.004), Model 3 (*P-trend* = 0.004), and Model 4 (*P-trend* = 0.009), significant results were also indicated. These *P-trend* values signified significant negative correlations as sleep duration

Table 7 Interactive effect of age in patients with stroke in two NHANES databases

Subgroups	Sleeptime, hours	with stroke		*P* for interaction	with stroke		*P* for interaction
		Crude OR_95CI%	Crude *P* value		Adjusted OR_95CI %	Adjusted *P* value	
Age in 2017–2020.03 (years)				**< 0.001**			**0.024**
< 60	< 7	1(Ref)			1(Ref)		
	7–9	0.94(0.57,1.552)	0.809		1.285(0.548,3.013)	0.565	
	> 9	0.985(0.688,1.41)	0.935		0.627(0.29,1.356)	0.235	
P-trend		0.890(0.800,0.990)	0.030		0.874(0.786,0.973)	0.014	
≥ 60	< 7	1(Ref)			1(Ref)		
	7–9	1.043(0.746,1.457)	0.807		0.75(0.433,1.298)	0.304	
	> 9	1.386(1.2,1.601)	**< 0.001**		1.171(0.874,1.569)	0.291	
P-trend		1.113(1.045,1.186)	< 0.001		1.105(1.033,1.182)	0.004	
Age in 2021.08–2023.08 (years)				**< 0.001**			**0.012**
< 60	< 7	1(Ref)			1(Ref)		
	7–9	0.708(0.343,1.461)	0.350		1.327(0.721,2.44)	0.363	
	> 9	1.666(1.318,2.106)	**< 0.001**		1.836(1.138,2.962)	**0.013**	
P-trend		1.101(0.958, 1.266)	0.177		1.066 (0.935, 1.212)	0.344	
≥ 60	< 7	1(Ref)			1(Ref)		
	7–9	1.076(0.746,1.551)	0.696		1.327(0.721,2.44)	0.363	
	> 9	1.301(1.115,1.517)	**< 0.001**		1.44(1.15,1.436)	**0.044**	
P-trend		1.208(1.122–1.300)	< 0.001		1.157 (1.07–1.252)	< 0.001	

The bold values denote statistically significant results at the predefined threshold ($P < 0.05$)

shifted from less than 7 h to 7–9 h and then to more than 9 h.

Subgroup analyses

In the 2018 CHARLS database, the diabetes subgroup had an interaction *P-value* of 0.006, showing its significant impact on the sleep-stroke risk relationship. In 2020, the hypertension subgroup's *P-value* was 0.003, indicating a notable influence on this association (Table 6). Before the COVID-19 pandemic, among individuals aged 60 years and above, a prolonged sleep duration of more than 9 h was positively correlated with stroke risk (unadjusted: $OR(95\%CI) = 1.239(1.06,1.447)$, $P = 0.007$; adjusted: $OR(95\%CI) = 1.342(1.132,1.59)$, $P = 0.01$ in 2018). But during the pandemic, this association lost significance. *P-trend* analyses showed a marked trend in the relationship between sleep duration and stroke risk among individuals under 60 years during non-pandemic periods in China (unadjusted: *P-trend* = 0.019; adjusted: *P-trend* = 0.044). After the pandemic, this trend shifted towards the population aged 60 years and above (unadjusted: *P-trend* = 0.012; adjusted: *P-trend* = 0.046).

RCS analysis

The RCS analysis indicated a non-linear association between sleep duration and stroke risk (*P for non-linear* < 0.001 in both the 2018 and 2020 databases), as shown in Fig. 2A and B.

Mediation effect analysis

Mediation analysis was conducted to explore the mediating effects of metabolic syndrome (hypertension, diabetes, and dyslipidemia). Dyslipidemia explained 16.83% and 8.3% of the associations in the 2018 and 2020 CHARLS databases respectively ($P < 0.001$), but its mediating effect weakened during the COVID-19 pandemic. Further analysis reveals that, Among individuals aged 60 years and older, dyslipidemia accounted for 20.25% and 8.39% of the association between sleep duration and stroke risk respectively. For individuals aged under 60, although the direct effects of dyslipidemia were significant ($P < 0.001$), the mediating effect was not significant ($P = 0.08$ in 2018 and $P = 0.17$ in 2020). Hypertension and diabetes showed no mediating effects.

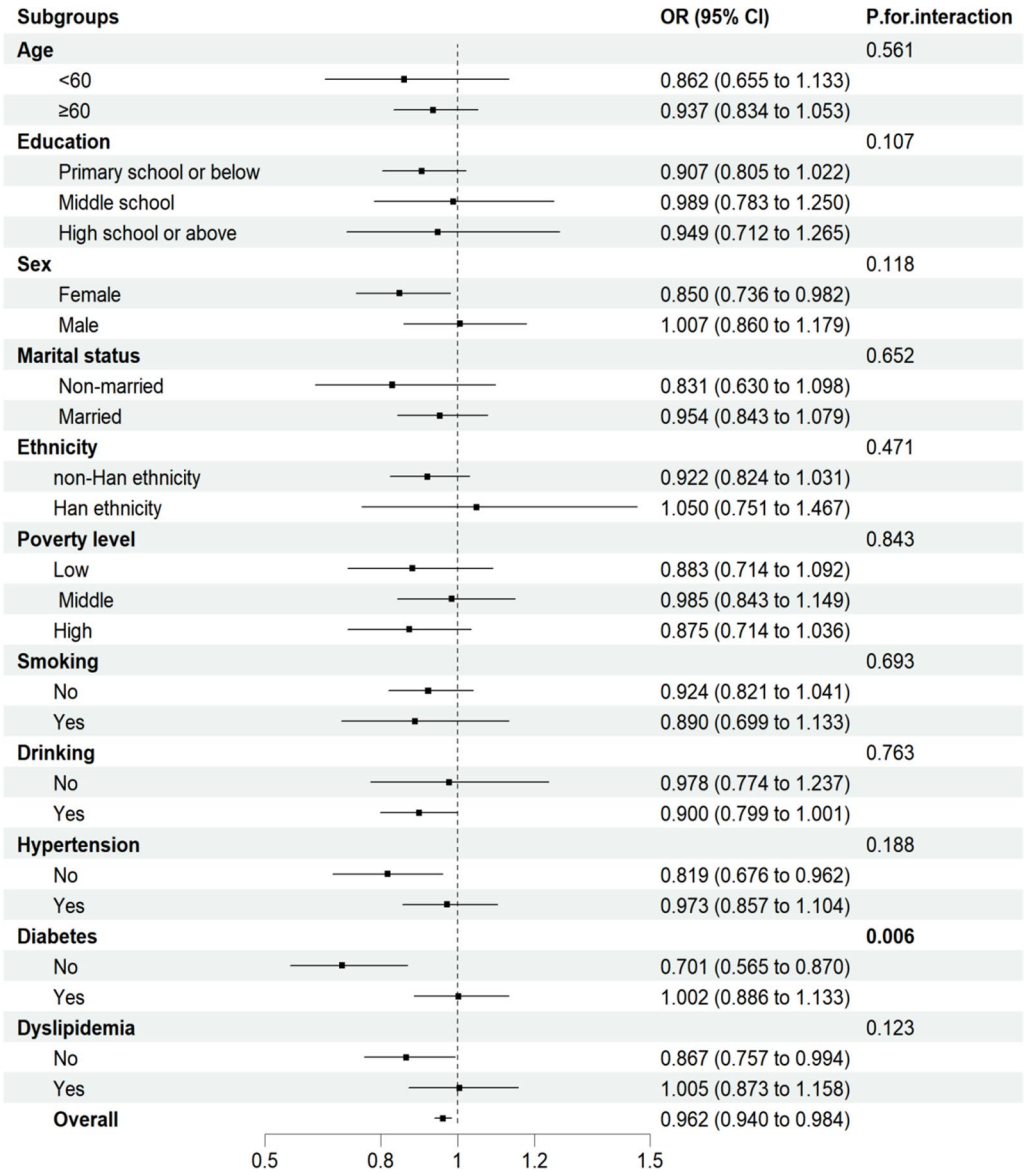

Fig. 3 Relationships between sleep duration and the incidence of stroke in the subgroup analysis of the 2018 database. The results of the subgroup analysis revealed a statistically significant interaction for diabetes (*P for interaction* = 0.006)

Results from NHANES data analysis

Baseline characteristics of the participants

There were 9131 participants in the NHANES study from 2017-March 2020 (mean age 51.07 ± 17.69 years; male: female ratio was 49.89%:50.11%), with 475 stroke patients and 8656 non-stroke patients. There were 7678 participants in the study from August 2021-August 2023 (male: female ratio was 44.45%:55.55%), with 360 stroke patients and 7318 non-stroke patients. Before and during the COVID −19 pandemic, the stroke group had a significantly higher proportion in age, proportion of married individuals, prevalence of diabetes, hypertension, and dyslipidemia, and lower educational levels, poorer economic conditions than the non-stroke group. In terms of sleep duration, the *P-values* were 0.014 and $P < 0.001$ respectively. For age, proportion of married individuals, diabetes, hypertension, dyslipidemia, lower educational levels, and poorer economic conditions, the *P-values* were all less than 0.001. The stroke group also had a significantly lower current alcohol consumption rate ($P < 0.001$). There were no significant differences in sex distribution ($P = 0.521$ vs. $P = 0.159$) and current smoking status ($P = 0.253$ vs. $P = 0.08$). The risk of stroke among the American population significantly increased with

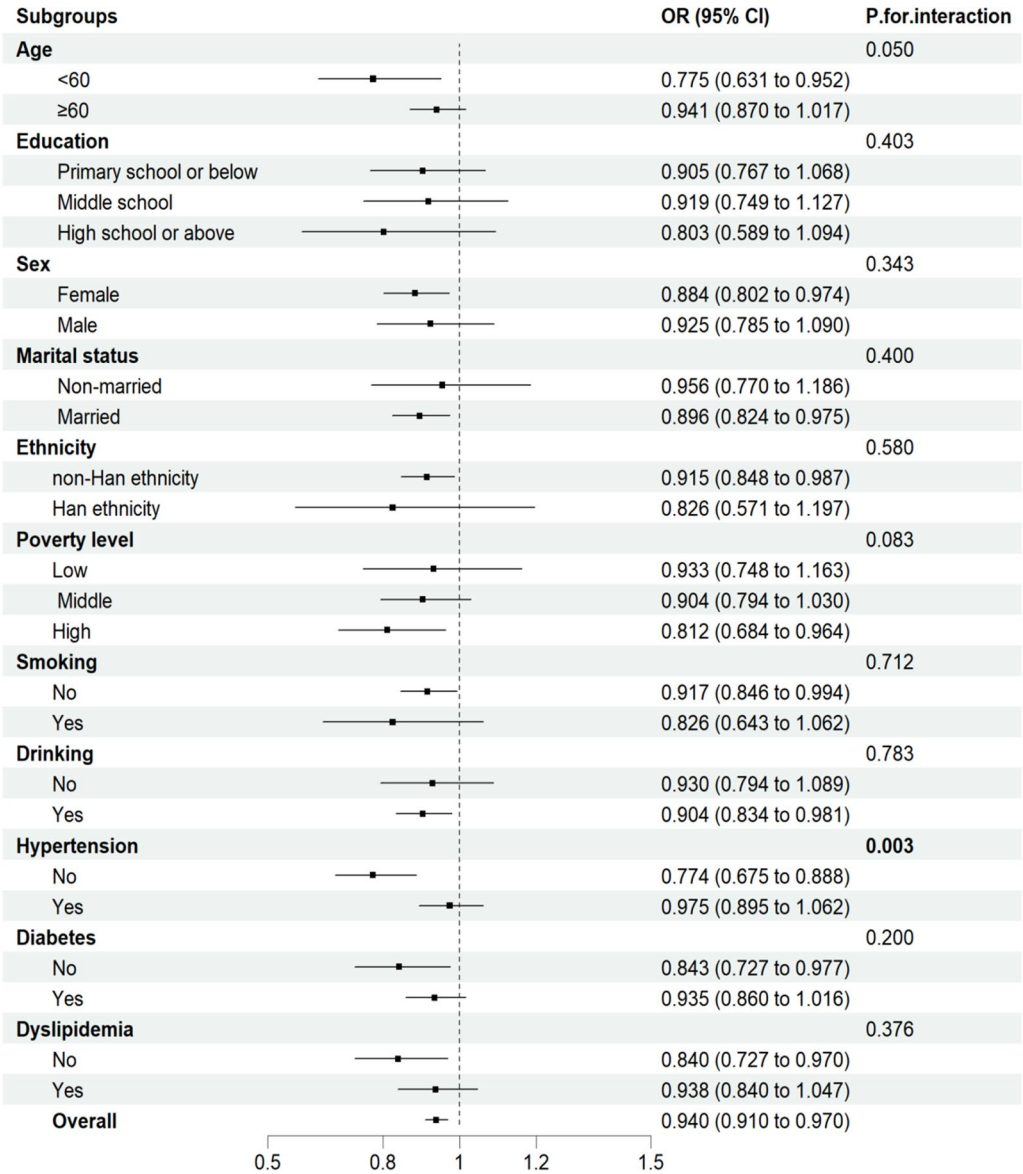

Fig. 4 Relationships between sleep duration and the incidence of stroke in the subgroup analysis of the 2020 database. The results of the subgroup analysis revealed a statistically significant interaction for hypertension (*P for interaction* = 0.003)

increasing sleep duration during the pandemic. Before the pandemic, the stroke risk was 5.47% (< 7 h), 3.93% (7–9 h), and 7.74% (> 9 h) respectively. During the pandemic, these values changed to 4.53%, 3.29%, and 8.17%.

Multivariate logistic regression analysis of sleep duration and stroke incidence

In the 2017–2020.03 database, compared with a sleep duration of less than 7 h, a 7–9-h sleep duration may be a protective factor: Model 1 (*OR*(95%CI) = 0.79 (0.63,0.99), *P* = 0.045), Model 2 (*OR*(95%CI) = 0.74 (0.58,0.94), *P* = 0.013), Model 3 (*OR*(95%CI) 0.75 (0.58,0.97), *P* = 0.026), Model 4 (*OR*(95%CI) = 0.77 (0.56,0.98), *P* = 0.040), while a sleep duration of more than 9 h may be a risk factor: Model 1 (*OR*(95%CI) = 1.63 (1.31,2.03), *P* < 0.001), Model 2 (*OR*(95%CI) = 1.28 (1.02,1.61), *P* = 0.033), Model 3 (*OR*(95%CI) = 1.13 (0.89,1.44), *P* = 0.32), Model 4(*OR*(95%CI) = 1.06(0.74,1.53), *P* = 0.736).In the 2021.08–2023.03 database, using a < 7-h sleep duration as a reference, a 7–9-h sleep duration may also have a protective effect: Model 1 (*OR*(95%CI) = 0.75 (0.57,0.99), *P* = 0.039), Model 2 (*OR*(95%CI) = 0.72

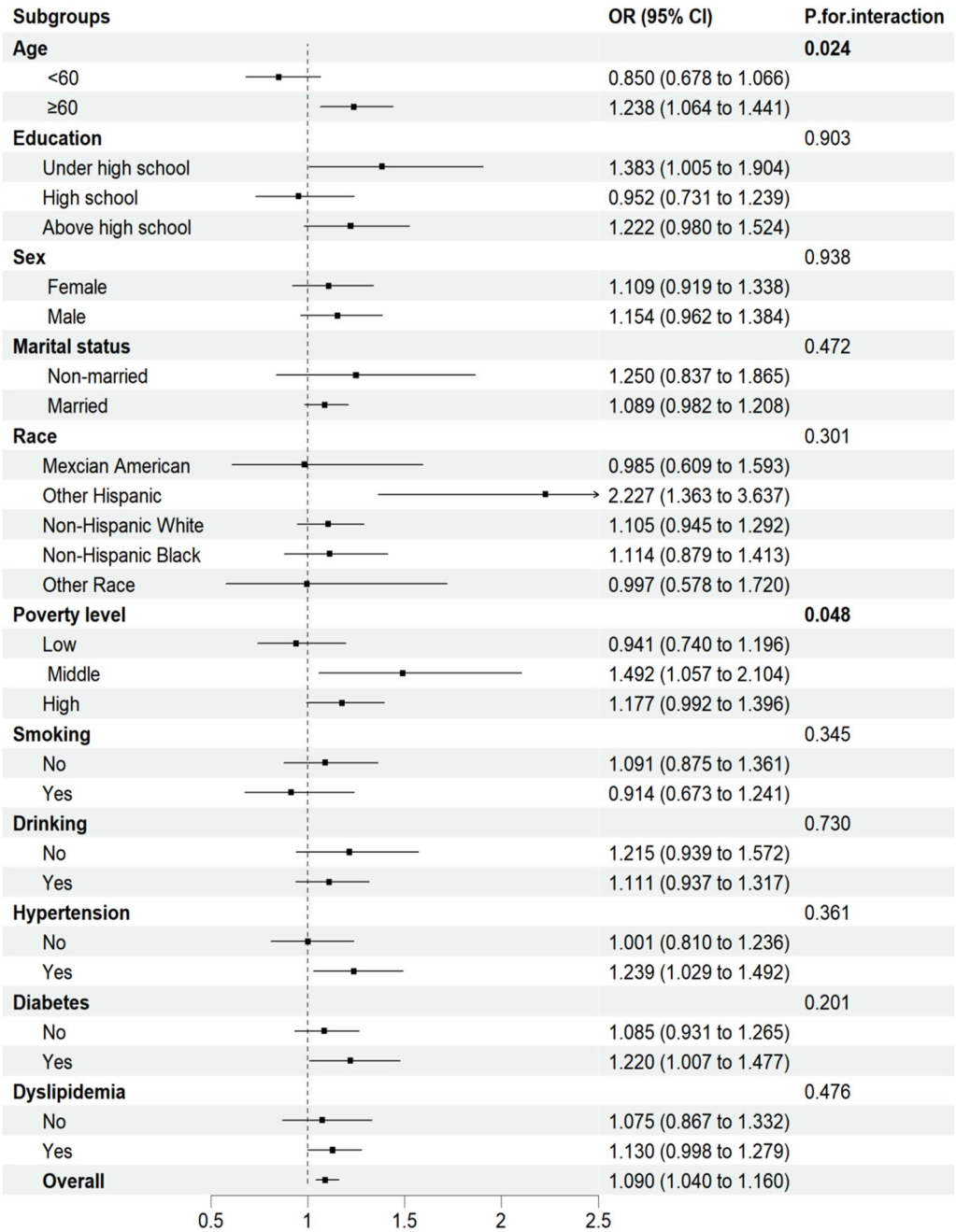

Fig. 5 Relationships between sleep duration and the incidence of stroke in the 2017–2020.03 database in the subgroup analysis. The results of the subgroup analysis revealed a statistically significant interaction test for age (*P for interaction* = 0.024) and poverty level (*P for interaction* = 0.048)

(0.55,0.96), $P=0.024$), Model 3 (OR(95%CI) = 0.78 (0.58,1.06), $P=0.11$), Model 4 (OR(95%CI) = 0.77 (0.57,1.04), $P=0.091$), and a sleep duration of more than 9 h may be a risk factor: Model 1 (OR(95%CI) = 2.04 (1.59,2.63), $P<0.001$), Model 2 (OR(95%CI) = 1.66 (1.28,2.15), $P<0.001$), Model 3 (OR(95%CI) = 1.57 (1.19,2.09), $P=0.002$), Model 4 (OR(95%CI) = 1.60 (1.20,2.12), $P=0.001$). This trend persisted after excluding the influence of sleep duration exceeding 2 standard deviations (OR: 1.00 vs. 0.77 vs. 1.60, $P<0.01$).

Subgroup analyses

In the 2017–2020.03 database, interactions were detected for age and poverty level ($P=0.024$ and $P=0.048$ respectively), and in the 2021–2023.08 database, an interaction for age was detected ($P=0.012$) (Table 7).From

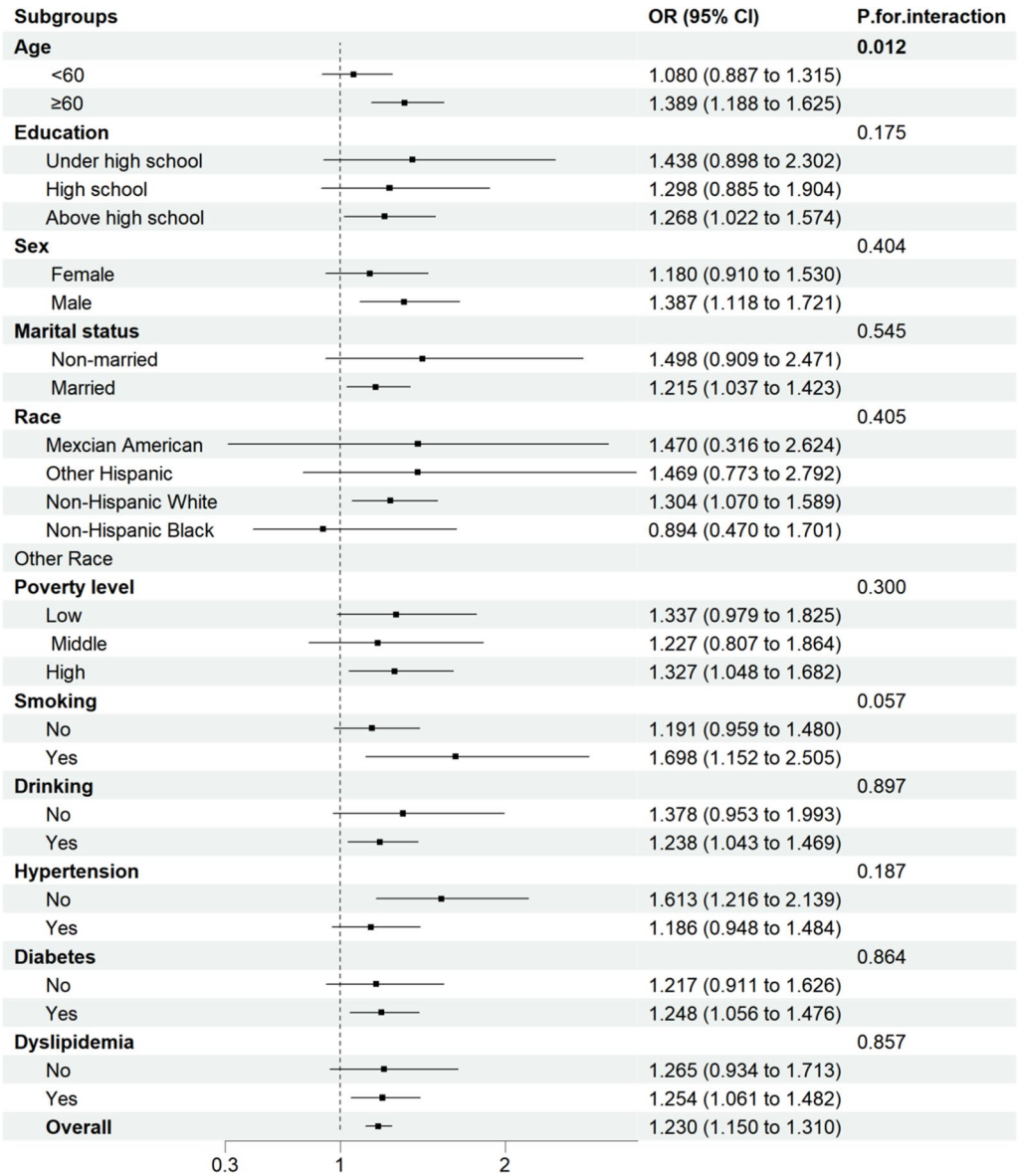

Fig. 6 Relationships between sleep duration and the incidence of stroke in the subgroup analysis of the 2021.08–2023.08 cohort. The results of the subgroup analysis revealed a statistically significant interaction test for age (*P for interaction* = 0.012)

2017–2020, among U.S. adults aged ≥ 60 years, a prolonged sleep duration (> 9 h) was considered a potential risk factor for stroke (unadjusted *OR*(95%CI) = 1.386 (1.20–1.601), $P < 0.01$; adjusted *OR*(95%CI) 1.171 (0.874, 1.569), $P > 0.05$). During in 2017–2020.03, an association was observed between sleep duration (> 9 h) and stroke risk regardless of age ($P < 0.05$). *P-trend* analyses showed an association between stroke risk and sleep-duration variations ($P < 0.05$). In fully adjusted models, the interaction effect was no longer statistically significant ($P = 0.203$).

RCS analysis

The results revealed a non-linear association between sleep duration and stroke risk (*P for non-linear* = 0.0217 in the 2017–2020.03 database; *P for non-linear* < 0.001 in the 2021.08–2023.03 database), as shown in Fig. 2C and D.

Mediation effect analysis

The mediation analysis indicates that diabetes has a mediation effect on the relationship between sleep duration and stroke of −0.00001 ($P = 0.00232$), with a proportion mediated of −0.0498%. The direct effect of sleep

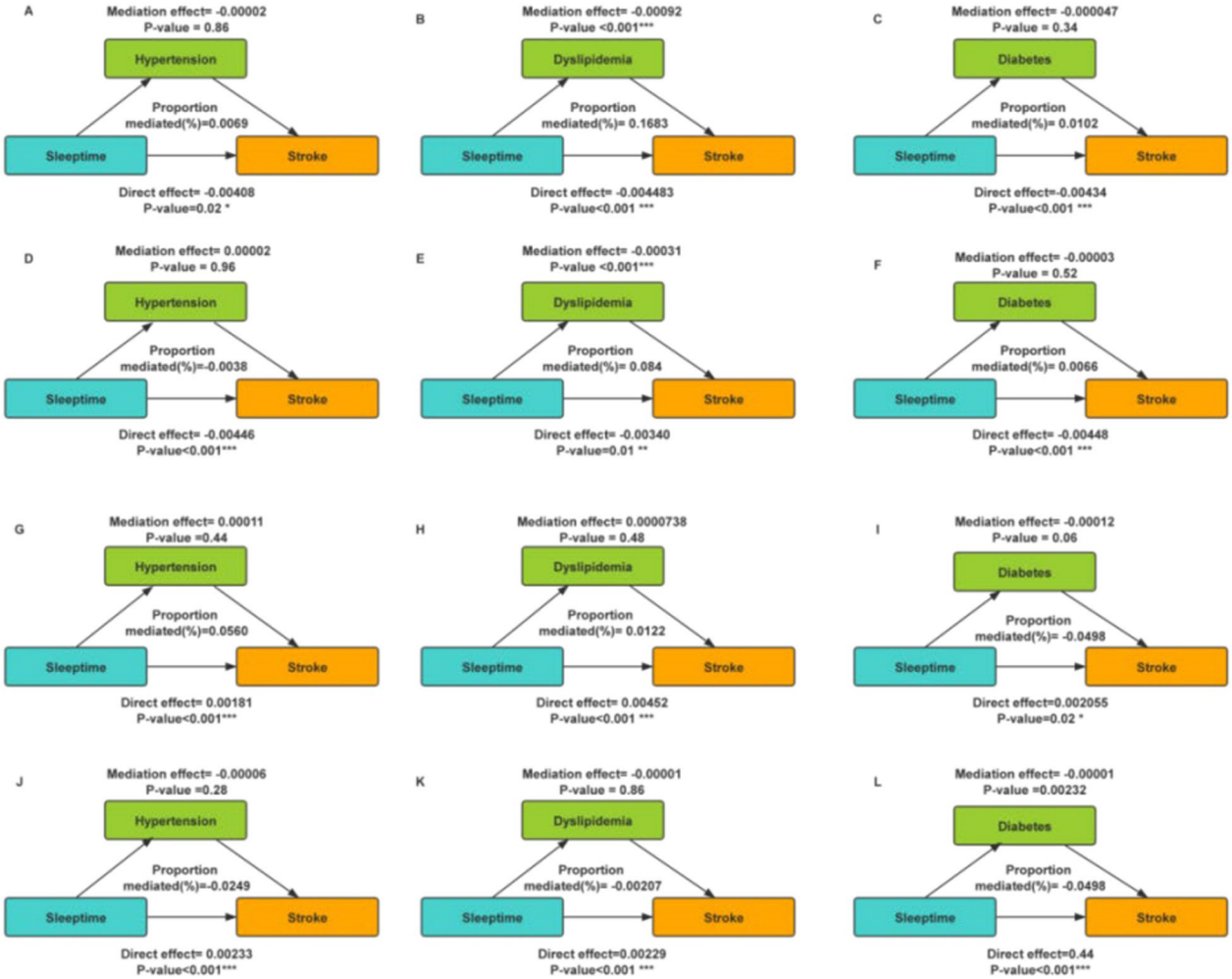

Fig. 7 Path diagram illustrating the mediation analysis of the relationship between sleep time and stroke risk across various years. The graphs (**A**–**C**) correspond to the 2018 CHARLS database; (**D**–**F**) to the 2020 CHARLS database; (**G–I**) to the 2017–2020.03 NHANES database; and (**J–L**) to the 2021.08–2023.08 NHANES database, each depicting the mediating effects of hypertension, dyslipidemia, and diabetes, respectively

duration on stroke is 0.44 ($P < 0.001$). Diabetes plays a statistically significant yet minor mediating role.

Discussion

Discussion of research on sleep duration and stroke risk

In this study, we compared data from CHARLS in China and NHANES in the US to explore sleep duration-stroke risk links before and during COVID—19. Results showed a "U-shaped" sleep -stroke prevalence association in both countries during the pandemic in multivariable-adjusted models. In the US, long sleep (≥ 9 h) during COVID-19 was a stroke risk factor, stronger in those under 60. In China, long-sleep-stroke association was stronger in non-pandemic for those 60 and above, with no link in those under 60. Mediation analysis in China indicated lipid abnormalities partially mediated this link, accounting for 8.39% overall and 20.25% in the 60 and above group. These findings contribute to knowledge and have implications for stroke prevention. Notably, this study is the first to incorporate comprehensive data on sleep duration and stroke risk, taking into account both non-COVID-19 and COVID-19 periods, sampling weights, and data from the general populations of China and the United States (Figs. 3, 4).

Research on the association between sleep duration and stroke risk has a long—standing history. However, the relationship between the two is intricate, being influenced by multiple factors such as genetics, socioeconomic conditions, and the environment. Consequently, research findings vary significantly across different regions and populations [2, 21]. Nonetheless, due to the reliance on cross—sectional data in some parts of the research, it is challenging to establish a causal relationship. Confounding factors such as mental health

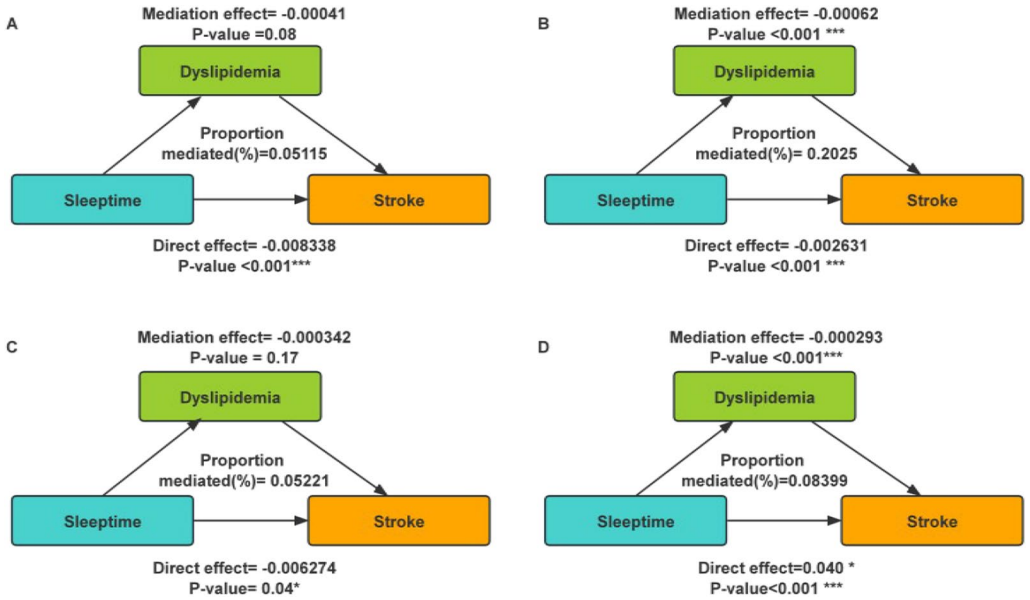

Fig. 8 Path diagram illustrating the mediation analysis of the relationship between sleep time and stroke risk across various years in the age groups. The graphs (**A**, **B**) correspond < 60 and ≥ 60 in the 2018 CHARLS database, The graphs (**C**, **D**) correspond < 60 and ≥ 60 in the 2020 CHARLS database, each depicting the mediating effects of dyslipidemia

status (e.g., chronic anxiety and depression), sleep quality (including sleep fragmentation and rapid-eye-movement sleep disorders), and physical activity levels (sedentary lifestyle versus regular exercise habits) often interfere with the determination of the association between sleep duration and stroke risk [22] (Figs. 5, 6).

While some studies define short sleep as less than five hours, others adopt six or seven hours as the threshold [2]. Moreover, certain studies have suggested that a relatively shorter sleep duration might be linked to a decreased risk of hemorrhagic stroke mortality, especially among male subjects [23, 24]. And this study did not find any significant differences between sexes (interaction $P > 0.05$) [6]. The dose–response analysis paradigm described in the BMJ Open Journal provides a powerful tool for understanding the complex relationship between sleep duration and stroke risk. This paradigm comprehensively aggregates data on different sleep durations and their corresponding stroke-risk frequencies, combines advanced statistical algorithms with a large number of samples, and constructs a highly accurate model. However, due to limitations in sample size, data collection scope, and the characteristics of the research subjects in this study, it is currently not possible to construct a dose–response model. Nevertheless, the non—linear correlation obtained from the RCS plot can, to some extent, explain the relationship between sleep duration and stroke risk. It is expected that future research will use this method to integrate various models to determine a more scientific and unified classification standard for sleep duration. In view of the current research inconsistencies and the need for comparability of research results among different populations, this study suggests that future cross—national studies adopt a unified sleep—duration threshold: less than 7 h is defined as short sleep, 7–9 h as normal sleep, and more than 9 h as long sleep. This standard is expected to enhance the comparability of future research results [25]. A large-scale cohort study published in JAMA Network Open, with over 320,000 adult participants involved, as per relevant research, indicated that a sleep duration of 7 h represents the optimal solution for reducing mortality rates from all—cause, cardiovascular diseases, and other causes, A Chinese study also confirmed this [26, 27].Therefore, in light of the existing research inconsistencies and the need for more comparable results across different populations, we propose that future transnational studies adopt a unified threshold for sleep duration: less than 7 h be defined as short sleep, 7–9 h as normal sleep, and more than 9 h as long sleep (Figs. 7, 8).

This study also explored the mediating role of the "three highs" (hypertension, hyperglycemia, and dyslipidemia) in the relationship between sleep duration and stroke risk. The results showed that among individuals aged over 60 in China, dyslipidemia played a mediating role between sleep duration and stroke risk, which was consistent with previous research [28]. Although the prevalence of metabolic syndrome is greater in the U.S.

population [29], this study did not find such an association. Overall, this study offers a novel perspective for understanding the relationship between sleep duration and stroke risk. In the future, longitudinal studies and comprehensive data collection can be adopted in subsequent research to address the existing limitations.

Influence of cultural and social factors on the sleep-stroke relationship

Similarly, there are differences in sleep patterns between European and Asian populations, leading to varying results [27, 30].This study has found that the cultural differences in pandemic prevention and control between China and the United States significantly influence sleep and stroke risks. Against the backdrop of China's collectivist culture, strict isolation measures effectively curbed the spread of the pandemic. However, the resulting home-bound living reduced people's physical activities and social interactions, causing changes in the sleep patterns of some individuals. In the United States, the flexible pandemic prevention and control measures, while alleviating psychological stress, increased the risk of virus transmission. Factors such as virus infections and the anxiety and depression triggered by the pandemic have complicated the relationship between sleep and stroke risk. In addition, cultural factors vary significantly across different regions. The siesta culture in Spain affects the circadian rhythm and cardiovascular function [31]. The high-pressure environment in South Korea leads to sleep deprivation, increasing the risk of stroke [32]. In equatorial countries, shorter sleep durations are more likely to affect the human biological clock and hormonal balance, thus increasing health risks [33].Future research should also be extended to regions with different cultural backgrounds such as Japan and Germany to verify and expand the research findings. In conclusion, when formulating stroke prevention strategies, cultural, social backgrounds, and geographical factors need to be fully considered, and the cultural values underlying sleep behaviors should be explored in depth.

Research limitations and future perspectives

This study has certain limitations in methods and data. In terms of data collection, this research used self—reported data to assess sleep duration and stroke incidence. This approach may be plagued by issues such as recall bias. To minimize bias as much as possible, during the collection of the NHANES questionnaire, CAPI system was employed, and the questionnaire survey was conducted in the respondents' homes. After the data collection was completed, office staff then reviewed the interview data on-site to ensure the accuracy and completeness of the selected items. A systematic review study indicates that, under specific populations and research designs, there is no significant difference between self-reported data and objectively measured results regarding disease outcomes such as stroke, diabetes, and hypertension [34].

This study, based on a cross-sectional research design and using logistic regression analysis methods, reveals a significant correlation between sleep duration and the prevalence of stroke. However, due to the limitations of the research design, it is impossible to establish a clear causal relationship between the two. Although multiple variables were controlled during the data analysis process, it remains challenging to rule out potential unidentified confounding factors, such as genetic factors, living environment factors, and dietary habit factors. In the future, longitudinal research designs or experimental research designs can be adopted to delve deeper into the causal association between them, laying a more solid theoretical foundation for the formulation of stroke prevention strategies.

Moreover, due to the differences in healthcare systems, cultural customs, and pandemic prevention and control measures among different countries, medical facilities also vary in the diagnosis and treatment of stroke. Currently, the results of this study are only applicable to China and the United States. Cultural norms shape sleep patterns, while pandemic prevention and control strategies influence people's sleep quality and health conditions. These factors all increase the difficulty of generalizing the research results. Therefore, readers should exercise caution when extrapolating the results beyond the countries where the data were collected.

For future research, objective monitoring devices such as polysomnography and actigraphy can be employed to obtain more accurate data on sleep duration, sleep quality, and sleep structure. Meanwhile, in research design and analysis, cultural, socioeconomic, and medical factors of various countries should be comprehensively considered to enhance the generalizability of the research results and provide effective support for the formulation of stroke prevention strategies. Additionally, through international collaborative research, data resources from all parties can be pooled to conduct more extensively representative studies.

Conclusion

In summary, this study emphasizes the complex relationships among sleep duration, pandemic status, sociocultural factors, and metabolic health in influencing stroke risk. This study highlights the importance of comprehensive health strategies and suggests that future strategies consider racial differences, age disparities, and variations in sociocultural contexts to effectively reduce the incidence of stroke.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13019-025-03376-z.

Additional file 1.

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Author contributions
J.B. conceptualized and designed the study, developing the overall research framework. X.L., D.Y., P.J., and J.W. were responsible for the collection, management, and analysis of the data, ensuring rigorous adherence to research protocols. J.B. authored the primary manuscript, articulating the study's findings and implications. G.L. provided supervision throughout the research process and conducted a thorough revision of the manuscript to enhance clarity and coherence. All authors participated in the critical review and approved the final version of the manuscript for publication.

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Availability of data and materials
No datasets were generated or analysed during the current study.

Declarations

Human ethics and consent to participate
Not applicable.

Competing interests
The authors declare no competing interests.

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