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ORIGINAL COMMUNICATION

Cumulative alcohol consumption and stroke risk in men

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Abstract

Backgrounds Views on the relationship between alcohol consumption and stroke risk remain controversial. Moreover, data on cumulative alcohol intake are limited. We examined the potential impact of cumulative alcohol consumption on the risk of total stroke and its subtypes in men.

Methods This prospective study included 23,433 men from the Kailuan Study. Cumulative alcohol consumption was taken as the primary exposure by calculating self-reported alcohol consumption from three consecutive examinations (in 2006, 2008, and 2010). The first occurrence of stroke was confirmed by reviewing medical records from 2010 to 2016. We used Cox proportional hazards regression to analyze the data.

Results During the 5.9 ± 0.8 years of follow-up, 678 total strokes were identified, including 595 ischemic stroke (IS), 90 intracerebral hemorrhage and 19 subarachnoid hemorrhage cases. The adjusted hazard ratios (95% confidence intervals) of total stroke for light, moderate and heavy cumulative alcohol consumption were 1.23 (1.01–1.51), 1.49 (1.13–1.97), and 1.50 (1.21–1.86), respectively, compared with those of nondrinkers. The results were similar for IS. Cumulative alcohol consumption was not associated with intracerebral hemorrhage risk (hazard ratio 1.46; 95% confidence interval, 0.74–2.08).

Conclusions Cumulative alcohol consumption is an independent risk factor of total stroke and IS in men in a community-based cohort. Even light alcohol intake increases the risk of total stroke and IS.

Keywords Prospective study · Ischemic stroke · Intracerebral hemorrhage · Alcohol consumption · Stroke

Introduction

Stroke is an important health and social problem around the world [1, 2]. More than 90% of stroke burdens are caused by modifiable risk factors [3, 4]. Therefore, investigation and control of risk factors that may prevent stroke occurrence are needed. Drinking, which is common worldwide, is one

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modifiable lifestyle factor. The per-capita alcohol consumption in China increased by 76% from 2005 to 2016 [5].

To date, the results of studies on the relationship between drinking and stroke remain inconsistent. The Physicians' Health Study stated that light–moderate alcohol consumption reduced the risk of total stroke and ischemic stroke (IS) but not intracerebral hemorrhage (ICH) [6]. More recent results from the prospective urban rural epidemiological (PURE) study showed no significant association between alcohol consumption and stroke [7]. In contrast, Angela et al. indicated that alcohol consumption was linearly associated with an increased stroke risk [8]. Meta-analyses argued that mild drinking decreased the incidence and mortality of stroke, whereas heavy drinking increased the risk of stroke [9, 10]. One reason for these inconsistent findings may be the use of baseline drinking to analyze the stroke risk. The effect of alcohol on stroke is a long process that requires accumulation of exposure. Moreover, the type, frequency and dose of alcohol intake may change. John et al. reported that 33% of drinkers had changed their drinking levels after 6 years of follow-up [11]. Therefore, measuring the risk of stroke based on baseline drinking levels may be less warranted.

Cumulative exposure is calculated based on the sum of products of the exposure dose levels and time to estimate the impact of exposure factors on outcome events [12]. At present, few studies have investigated the effects of cumulative alcohol consumption on stroke. Herein, we analyzed the association between cumulative alcohol consumption and the risk of stroke and its subtypes in men.

Methods

Study population

The Kailuan Study is a prospective, community-based, cohort study with an aim of exploring risk factors for cardiovascular and cerebrovascular diseases that was initiated in 2006. The study involves 101,510 employees of the Kailuan group (Tangshan, Hebei, China) aged 18–98 years. Subsequent medical examinations took place in 2008–2009 (second) and 2010–2011 (third), which included face-to-face questionnaire assessments, physical examinations and blood tests. A total of 57,927 participants completed the first three examinations. We excluded 34,494 participants, including women (n = 13,595, because 93.2% of women reported they were nondrinkers), those missing alcohol information on any of the three examinations questionnaires (n = 17,944), and those with a diagnosis of stroke or cancer before the third examination (n = 1337). Due to heterogeneity among the former drinkers, these participants were also excluded (n = 1618). The final sample consisted of 23,433 men. Written informed consent was provided by all participants.

Assessment of alcohol intake and covariates

In the face-to-face interviews, all participants were asked to report the following information using a standardized questionnaire: whether they had drank alcoholic beverages within the last year, the beverage type (wine, beer, high-alcohol liquor, and low-alcohol liquor), their drinking frequency (times per day/week/month) and the average amount consumed per time. Alcohol consumption was calculated in grams per day by multiplying the average frequency per day by the average amount consumed at each time and the ethanol content (10% for wine, 4% for beer, 52% for high-alcohol liquor and 38% for low-alcohol liquor) [13]. To represent long-term alcohol exposure of individuals, we calculated cumulative alcohol consumption using a method similar to the calculation method for cumulative blood pressure exposure [14] as follows: [(alcohol1 + alcohol2)/2 × time1–2] + [(alcohol2 + alcohol3)/2 × time2–3], where alcohol1, alcohol2 and alcohol3 indicate self-reported alcohol consumption at the first, second and third examination and time1–2 and time2–3 indicate the time intervals between the two adjacent examinations, respectively.

Similar to previous studies [15], an average daily alcohol intake > 0 to < 15 g/day was defined as light consumption, ≥ 15 to < 30 g/day was defined as moderate consumption and ≥ 30 g/day was defined as heavy consumption. According to the cumulative alcohol consumption (g/day × year), the participants were divided into the following four groups: nondrinkers, light (> 0 to < 15 g/day × 4 year), moderate (≥ 15 to < 30 g/day × 4 year), and heavy (≥ 30 g/day × 4 year).

Follow-up and stroke assessment

Follow-up began at the third medical examination in 2010–2011 and continued until the first occurrence of fatal or nonfatal stroke, death or December 31, 2016. The follow-up was carried out by trained doctors who were blinded to the participants' data. The stroke incidence was obtained from the biannual questionnaire survey, Municipal Medical Insurance record, Hospital Discharge Register centers, and Provincial Bureau of Life Statistics. The diagnosis of stroke was confirmed by computed tomography and/or magnetic resonance imaging in accordance with the World Health Organization diagnostic criteria [16] and was further divided into IS, ICH, or subarachnoid hemorrhage (SAH). In the current study, we did not analyze SAH separately due to the small sample size (n = 19); instead the event was counted as a total stroke. For one participant, the first incident of IS, ICH and SAH was recorded, respectively, but only the earliest stroke event (IS, ICH or SAH) was recorded as total stroke.

Covariates

Information on age, education, physical exercise, income, smoking status and salt intake was collected using questionnaires. We measured the participant's weight and height and calculated their body mass index (BMI) as weight (kg)/height (m^2). Venous blood samples were collected after an overnight fast (> 8 h) into vacuum tubes containing EDTA. The low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), total cholesterol (TC), triglyceride, and plasma glucose levels were measured at the central laboratory of Kailuan General Hospital with an autoanalyzer (Hitachi 747; Tokyo, Japan). Diabetes was defined as a participant taking hypoglycemic medications or a fasting glucose higher than 7.0 mmol/L or non-fasting glucose higher than 11.1 mmol/L. Hypertension was defined as a participant taking antihypertensive medications or systolic blood pressure (SBP) higher than 140 mmHg or diastolic blood pressure (DBP) higher than 90 mmHg.

Statistical analysis

Continuous variables are reported as the mean ± standard derivation (SD), and one-way analysis of variance (ANOVA) or the Wilcoxon test was used for comparisons between groups. Categorical data are summarized using percentages and were compared using the Chi-square test. Cox proportional hazards models were used to examine the associations between cumulative alcohol consumption and total stroke, IS and ICH by calculating the hazard ratios (HRs) and 95% confidence intervals (CIs), nondrinkers drinking was used as the reference category. Multivariable models were adjusted for age, smoking status, salt intake, income, physical exercise, education, BMI, LDL-C, diabetes and hypertension. The proportional hazards assumption was satisfied.

Further adjustments were made by adding a single measure of alcohol intake in 2006 or 2010 examination to observe the independent effect of cumulative exposure. To observe whether there is a linear relationship between cumulative alcohol consumption and stroke, we analyzed the relationship between cumulative alcohol exposure, treated as a continuous variable, per standard deviation (SD) increase and stroke in the models, separately. The fitting degree of the model was analyzed using likelihood ratio test. We also examined the relationship between baseline alcohol consumption (in 2006) or single alcohol consumption (in 2010) and the future stroke risk.

In general, smoking itself is a risk factor for stroke, and we have also observed that the proportion of smokers increased significantly in the heavy group. The sensitivity analysis was conducted by excluding smokers. Since hypertension and diabetes are traditional risk factors for stroke, we excluded patients with hypertension, diabetes, taking antihypertensive or hypoglycemic medications for sensitivity analysis, respectively. Since chronic heavy drinking leads to liver damage, participants with abnormal liver function (aspartate transaminase level greater than two times the upper limit of normal) at baseline were excluded from the sensitivity analysis.

We used SAS version 9.3 (SAS Institute, Cary, NC, USA) to analyze all data. A two-sided $P < 0.05$ was considered statistically significant.

Results

The mean age was 49.5 ± 11.8 years for the 23,433 participants. Almost two-fifths of the participants were nondrinkers. Approximately one-third of the participants reported that they were light alcohol drinkers, and 22% reported heavy alcohol consumption (≥ 30 g/day year). The participants in the light group were slightly younger. People who reported light or moderate drinking had a higher education level and income than the nondrinkers and heavy drinkers. A total of 59.6% of the heavy drinkers but only 20.1% of the nondrinkers self-reported current smoking. Blood pressure, salt intake, TC and HDL-C increased across the cumulative alcohol consumption levels ($P < 0.05$) (Table 1).

Table S2 shows the comparison of the characteristics of participants with and without alcohol consumption data. The individuals included in our study were older than the excluded participants and had higher education and SBP, DBP, LDL-C, HDL-C and fasting blood glucose levels. The proportion of smokers was lower and the proportion of those with hypertension and diabetes was higher among the included participants.

During the 5.9 ± 0.8 years of follow-up, we documented 678 total strokes, including 595 IS, 90 ICH and 19 SAH cases. Compared with those of the nondrinkers, significant associations were found between cumulative alcohol consumption and total stroke in the light (HR 1.23, 95% CI 1.01–1.51), moderate (HR 1.49, 95% CI 1.13–1.97), and heavy (HR 1.50, 95% CI 1.21–1.87) groups after adjustment for age, income, physical exercise, smoking, salt intake, education, BMI, LDL-C, diabetes, and hypertension (Table 2). In addition, the estimated impact of cumulative alcohol consumption on IS was similar to that on total stroke (Table 2). Heavy drinking was associated with a 46% increase relative to ICH compared with that of the nondrinkers, but the confidence intervals overlapped the null. Further adjustment for alcohol intake in 2006 or 2010 obtained similar results for the risk of IS, and cumulative alcohol consumption

Table 1 Baseline (in 2006) characteristics according to cumulative alcohol consumption categories among 23,433 participants

	Cumulative alcohol consumption				
	Nondrinkers	Light	Moderate	Heavy	*P* value
N, %	9456 (40.4)	6641 (28.3)	2176 (9.3)	5160 (22.0)	
Age, year	53.8 ± 12.1	46.9 ± 12.1	47.1 ± 11.4	48.5 ± 8.9	< 0.001
BMI	25.3 ± 3.5	25.3 ± 3.5	25.5 ± 3.4	25.1 ± 3.2	< 0.001
SBP, mmHg	132 ± 20	128 ± 19	130 ± 20	131 ± 19	< 0.001
DBP, mmHg	84 ± 11	83 ± 11	84 ± 12	85 ± 11	< 0.001
FPG, mmol/L	5.47 ± 1.72	5.44 ± 1.51	5.52 ± 1.49	5.46 ± 1.38	0.254
TC, mmol/L	4.83 ± 1.11	4.85 ± 1.15	5.02 ± 1.12	5.07 ± 1.26	< 0.001
HDL-C, mmol/L	1.52 ± 0.40	1.51 ± 0.38	1.56 ± 0.39	1.62 ± 0.41	< 0.001
LDL-C, mmol/L	2.27 ± 0.93	2.40 ± 0.81	2.44 ± 0.81	2.42 ± 0.83	< 0.001
Education, %					< 0.001
Elementary school or below/junior high school	88.2	73.0	73.2	82.6	
Senior high school	8.9	17.1	16.0	12.9	
College/university	2.9	9.9	10.8	4.5	
Physical activity, %					< 0.001
Never	6.4	10.5	13.1	14.6	
1–2 times/week	79.1	74.1	72.8	71.5	
≥ 3 times/week	14.5	15.4	14.0	14.0	
Average income, %					< 0.001
< 800 yuan/month	89.9	83.2	81.1	84.4	
≥ 800 yuan/month	10.1	16.8	18.9	15.6	
Salt intake, %					< 0.001
Low	7.6	10.2	10.8	10.4	
Moderate	84.4	77.7	73.9	72.9	
High	8.0	12.1	15.3	16.7	
Smoking status, %	20.1	37.9	52.6	59.6	< 0.001
Hypertension, %	46.7	39.6	42.3	44.4	< 0.001
Diabetes, %	9.9	8.3	7.9	7.5	< 0.001

Data shown as mean ± SD or frequency (percentage)

SBP systolic blood pressure, *DBP* diastolic blood pressure, *BMI* body mass index, *FBG* fasting blood glucose, *TC* total cholesterol, *HDL-C* high-density lipoproteincholesterol, *LDL-C* low-density lipoproteincholesterol

increased the risk of total stroke, except for the light drinkers (Table 2).

Each 1-SD (135 g year) change in cumulative alcohol consumption increased the risk for total stroke by 1.11-fold (95% CI 1.04–1.20), for IS by 1.12-fold (95% CI 1.04–1.21), and for ICH by 1.10-fold (95% CI 0.89–1.36) in the fully adjusted model.

In the multivariable Cox regression model adjusted for the aforementioned covariates, the fitting degree of the cumulative alcohol exposure model for both total stroke and IS was better than that of the baseline alcohol consumption model ($P < 0.05$) (Table 3).

We used the baseline (2006) or single (2010) alcohol consumption as the exposure factor and found that only heavy alcohol consumption increased the total stroke and IS risk. Conversely, no significant association was found between light alcohol consumption and the risk of total stroke and its subtypes (Table 4).

We observed similar results in the sensitivity analysis by separately excluding those who were current smokers, had hypertension or diabetes, used antihypertensive or hypoglycemic medications, or had abnormal liver function at baseline (Table S1).

Discussion

We confirmed that cumulative alcohol exposure was an independent risk factor for total stroke and IS over a 5.8-year follow-up in this large-scale, community-based, prospective study including 23,433 Chinese men. Our new finding was that even light cumulative alcohol exposure increased the

Table 2 Adjusted hazard ratios and 95% confidence intervals for stroke risk according to the cumulative alcohol consumption during 2006 to 2010 among 23,433 participants

	Cumulative alcohol consumption					
	Non-drinkers ($n=9456$)	Light ($n=6641$)	Moderate ($n=2176$)	Heavy ($n=5160$)	*P* trend	1 SD increase[b]
Total stroke						
Case, n	281	164	67	166		
Incidence/100,000 peson-year	516.5	418.9	525.9	547.4		
Age adjusted	1.00	1.17 (0.96–1.42)	1.48 (1.13–1.94)	1.52 (1.25–1.86)	<0.001	1.14 (1.06–1.22)
Fully adjusted model[a]	1.00	1.23 (1.01–1.51)	1.49 (1.13–1.97)	1.50 (1.21–1.86)	<0.001	1.11 (1.04–1.20)
Further adjusted of alcohol intake in 2006[a]	1.00	1.21 (0.98–1.50)	1.44 (1.05–1.97)	1.44 (1.11–1.88)	0.007	1.06 (0.97–1.16)
Further adjusted of alcohol intake in 2010[a]	1.00	1.22 (0.98–1.51)	1.45 (1.06–1.99)	1.46 (1.12–1.90)	0.006	1.06 (0.97–1.16)
Iischemic stroke						
Case, *n*	238	147	64	146		
Incidence/100,000 peson-year	436.7	375.0	501.9	480.5		
Age adjusted	1.00	1.25 (1.01–1.54)	1.70 (1.28–2.24)	1.60 (1.30–1.99)	<0.001	1.15 (1.06–1.23)
Fully adjusted model[a]	1.00	1.32 (1.06–1.63)	1.69 (1.26–2.25)	1.56 (1.24–1.97)	<0.001	1.12 (1.04–1.21)
Further adjusted of alcohol intake in 2006[a]	1.00	1.29 (1.03–1.62)	1.62 (1.16–2.25)	1.50 (1.13–1.99)	0.006	1.05 (0.95–1.16)
Further adjusted of alcohol intake in 2010[a]	1.00	1.30 (1.03–1.63)	1.64 (1.18–2.27)	1.51 (1.14–2.01)	0.005	1.07 (0.97–1.18)
Intracerebral hemorrhage						
Case, *n*	41	20	6	23		
Incidence/100,000 peson-year	74.5	50.6	46.6	75.0		
Age adjusted	1.00	0.87 (0.50–1.50)	0.80 (0.34–1.90)	1.26 (0.74–2.13)	0.467	1.07 (0.88–1.30)
Fully adjusted model[a]	1.00	0.98 (0.56–1.72)	0.92 (0.38–2.23)	1.46 (0.83–2.57)	0.234	1.10 (0.89–1.36)
Further adjusted of alcohol intake in 2006[a]	1.00	0.98 (0.55–1.78)	0.93 (0.35–2.41)	1.46 (0.74–2.90)	0.277	1.14 (0.90–1.45)

[a]Adjusted for age, income (<800 yuan/month, ≥800 yuan/month), exercise (never, 1–2 times/week, ≥3 times/week), smoking status (current, past, or never), salt intake (low, medium, and high), education (elementary school or below/junior high school, senior high school, college/university), BMI (kg/m^2), LDL-C (mmol/L), diabetes, and hypertension (yes or no)

[b]Treated cumulative alcohol exposure as a continuous variable

Table 3 Predictive value of the Cox regression models

	Total stroke LR X^2	*P*	Ischemic stroke LR X^2	*P*	Intracerebral hemorrhage LR X^2	*P*
Cumulative alcohol consumption model	411.25		376.25		45.39	
Baseline alcohol consumption (in 2006) model	405.32	<0.05*	369.11	<0.05*	43.21	>0.05*
Single alcohol consumption (in 2010) model	404.35	<0.05*	364.19	<0.05*	48.55	>0.05*

Adjusted for age, income (<800 yuan/month, ≥800 yuan/month), exercise (never, 1–2 times/week, ≥3 times/week), smoking status (current, past, or never), salt intake (low, medium, and high), education (elementary school or below/Junior high school, senior high school, college/university), BMI (kg/m^2), LDL-C (mmol/L), diabetes, and hypertension (yes or no)

LR likelihood ratio

[a]Compare the fitting degree with the cumulative alcohol consumption model

risk of stroke. Moreover, this relationship was independent of other traditional stroke risk factors, such as diabetes and hypertension.

Our study showed that light, moderate, and heavy cumulative alcohol exposure increased the risk of total stroke by 23%, 49%, and 50%, respectively. Compared with that of the

Table 4 Adjusted hazard ratios and 95% confidence intervals for stroke risk according to the alcohol consumption in 2006 or 2010

	Alcohol consumption				
	Nondrinkers	Light	Moderate	Heavy	*P* trend
In 2006, *n*	14,025	4918	527	3963	
Total stroke[a]	1.00	1.06 (0.84–1.35)	0.63 (0.34–1.15)	1.45 (1.16–1.92)	0.453
Iischemic stroke[a]	1.00	1.10 (0.86–1.41)	0.72 (0.39–1.32)	1.52 (1.20–1.92)	< 0.001
Intracerebral hemorrhage[a]	1.00	0.90 (0.46–1.75)	0.47 (0.36–3.43)	1.26 (0.66–2.97)	< 0.001
In 2010, *n*	14,571	1136	1067	6659	
Total stroke[a]	1.00	0.83 (0.50–1.37)	1.51 (1.09–2.07)	1.27 (1.05–1.53)	0.453
Ischemic stroke[a]	1.00	0.85 (0.50–1.45)	1.56 (1.12–2.19)	1.32 (1.08–1.61)	< 0.001
Intracerebral hemorrhage[a]	1.00	0.69 (0.67–2.88)	1.38 (0.55–3.47)	1.22 (0.73–2.05)	< 0.001

[a]Adjusted for age, income (< 800 yuan/month, ≥ 800 yuan/month), exercise (never, 1–2 times/week, ≥ 3 times/week), smoking status (current, past, or never), salt intake (low, medium, high), education (Elementary school or below/Junior high school, senior high school, college/university), BMI (kg/m^2), LDL-C (mmol/L), diabetes, and hypertension (yes or no)

nondrinkers, light cumulative alcohol consumption (equivalent to < 15 g/day) was not a protective factor but instead was a risk factor for total stroke. Although light cumulative drinking was not reported to be a risk factor for stroke previously, the relevant researches were in accordance with our findings. Recently, the *Lancet* published a study that analyzed the relative risks for 23 health outcomes associated with alcohol use from 1990 to 2016 in 195 countries and regions and found that the risk of IS increased with alcohol intake [17]. The study noted that there was no safe dose of alcohol intake, which supported our findings. Another large study comprised of 83 prospective cohort studies involving nearly 600,000 participants in 19 high-income countries showed an approximately linear relationship between alcohol consumption and a 14% increased risk of stroke (100 g/week increase in alcohol intake) [8]. Our study observed that every additional 135 g of alcohol consumed per year increased the incidence of total stroke by 11%. Our results were also in line with those of Mendelian randomization studies [18].

Furthermore, we investigated the alcohol–stroke relationship by distinguishing between IS and ICH. The association between cumulative alcohol exposure and IS incident was significant, but the same results were not found for ICH. Previous studies demonstrated protective effects of rare and moderate alcohol intake for ICH [19] or a lack of a significant relationship [6,20] and found that a heavy intake was associated with an increased ICH risk [20]. Since the sample size of ICH is small (n = 90), the results for total stroke are biased towards those obtained from IS. The Kailuan Study is ongoing, and new findings are expected as the ICH cases increase.

In addition, we analyzed the relationship between single alcohol consumption in 2006 or 2010 and the stroke risk and found that moderate and heavy but not light alcohol consumption was a risk factor of stroke. Previous studies based on baseline drinking were concordant with our results [7, 21]. Taking a single measure of exposure most likely underestimates the alcohol–stroke relationship. Ignoring the fact that drinking habits may change over time can lead to an erroneous classification of total alcohol intake and an estimate of the bias on the endpoint events [21]. In the present study, 39.8% of the subjects changed from their baseline drinking group after the observation period (more than 4 years). Among them, 16.4% of the participants drank less, and 23.4% drank more. Measurement of cumulative exposure can be quantified by considering the duration and intensity of exposure at the same time, and additional information may be generated [22]. Therefore, mid- to long-term exposure to alcohol may more accurately and truly indicate the stroke risk than assessment at a single timepoint several years before the occurrence of the event. Other studies have used this method, including those investigating cumulative smoking exposure and lung cancer, cumulative hyperglycemia exposure and diabetes complications, and cumulative hypertension exposure and the urinary-to-creatinine ratio [14,23–25] Our findings utilized the cumulative exposure method to reflect an individual's prolonged alcohol exposure status accurately and provided evidence for clinical and public health recommendations to advocate a healthier lifestyle.

The possible mechanisms by which alcohol consumption can increase the stroke risk are as follows: functional impairment of vascular endothelial cell, promotion of inflammation, development of atrial fibrillation and elevation of blood pressure. Our previous data demonstrated that light drinking increased the hypertension risk similar to moderate and heavy drinking in men [26].

Our research has several advantages, including a large sample size, a broad age range, excellent follow-up, a prospective design in an Asian population and calculation of cumulative exposure to minimize dose-dependent exposure to random errors. Moreover, the outcome events were confirmed more accurately by examining medical records and imaging data than by self-reporting since the Kailuan Medical Group health insurance covered all participants.

However, several limitations should be considered. First, the Kailuan Study was based on data from a single community, and data from women were limited. Our results may need to be confirmed in other populations. Second, to give consideration to both exposure and follow-up time, the cumulative alcohol consumption was only observed for a period of time in current study. It is expected that further studies will be conducted in different populations and a longer period of cumulative alcohol exposure to verify our results. Third, self-reporting alcohol consumption may lead to misclassification. Furthermore, we had low power to observe the effects of drinking types on stroke because fewer participants consumed only beer or wine. We also did not analyze the differences between episodic and regular drinking. Finally, residual confounding could not be excluded, although we adjusted for major confounders.

In conclusion, our results provide evidence that cumulative alcohol exposure increases the risk of total stroke and IS. Even light cumulative alcohol exposure increases this risk. Our data support limiting alcohol consumption and lowering the recommendation in the guidelines.

Compliance with ethical standards

Conflicts of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Ethical standards This study followed the ethical standards of the Declaration of Helsinki and was approved by the Ethics Committee of Kailuan General Hospital.

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