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ORIGINAL ARTICLE
Population Science

Relationship of Ambient Temperature Parameters to Stroke Incidence in a Japanese Population
— Takashima Stroke Registry, Japan, 1988–2010 —

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Background: Using a population-based stroke registry system, we evaluated the relationship between ambient temperature parameters and stroke incidence in a Japanese population.

Methods and Results: We analyzed data from the Takashima Stroke Registry, which records all stroke occurrences in Takashima City, Japan. The study period of 8,401 days was divided into quintiles of daily weather parameters, and the middle quintile was used as the reference category. Incidence rates (IR per 100,000 person-years) were calculated across the quintiles. Poisson regression analysis was used to calculate the effect of temperature parameters on stroke incidence. There were 2,405 first-ever strokes (1,294 men), including 1,625 ischemic, 545 cerebral hemorrhages, 213 subarachnoid hemorrhages, and 22 unclassified strokes. The stroke IR was higher in the middle quintile of average temperature, 357.3 (328.4–388.8), and for other parameters. After adjustment for age and sex, for all stroke, the incidence rate ratio (IRR) in the highest (Q5: IRR 0.81, 95% confidence interval (CI) 0.71–0.92) and the second-highest (Q4: IRR 0.80, 95% CI 0.71-0.91) quintile was lower than that in the middle quintile (Q3: Reference). Analogous results were observed for the minimum, maximum, and lag-days temperatures, also in the subtypes and across ≥65 years of age, also in females.

Conclusions: Higher temperatures, irrespective of the parameter (average, minimum, or maximum), had a protective effect against stroke occurrence in Japan.

Key Words: Ambient temperature parameters; Population-based study; Stroke incidence; Stroke subtypes

Stroke is the second leading cause of death globally and was responsible for 11% of the 55.4 million global deaths in 2019.[1] Absolute numbers of stroke and burden by death and disability-adjusted life years lost show an increasing trend from 1990 through 2010.[2] In Japan, stroke is still one of the major causes of death[3] and morbidity.[4]

Meteorological parameters affect human health, and studies have evaluated this relationship.[5,6] In particular, the effect of air pollution and atmospheric pressure, as well as temperature, on stroke.[7,8] Japan has 4 distinctive seasons with variations of temperature from day to day. In addition, elderly people are greater in number; as of October 1, 2018, the population over the age of 65 years comprised nearly one-third (28.1%) of the total population.[9] Elderly people are more vulnerable to stroke due to change in hemodynamics.[10] Moreover, abrupt changes in temperature cause respiratory infections.[11] In earlier reports, a relationship between such infections and the occurrence of acute stroke was observed.[12]

Regarding stroke, the effect of meteorological factors has studied both outside[8,13,14] and inside Japan.[15–23] The relationship between seasonal variation and stroke incidence,[15–17] and weekly variations of temperature on stroke onset[18] have been also studied. In particular for ambient temperature, hourly,[19,20] daily mean of maximum tempera-

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ture,[21] monthly,[22] and annual[23] mean of ambient temperature data of a town have been analyzed rather than daily temperature parameters. Moreover, previous data are mostly limited to hospital admission, ambulance record or mortality.[18–22] An ongoing, geographically defined, population-based surveillance registry would be appropriate to study the relationship between daily ambient temperature and stroke risk.

The objective of this study was to evaluate the relationship between the daily ambient temperature parameters and stroke incidence in a geographically defined, semi-urban and rural Japanese population using a population-based stroke registry.

Methods

Takashima Stroke Registry

The Takashima Stroke Registry[24,25] is an ongoing population-based registry and an integrated part of the Takashima Cardiocerebrovascular Disease Registration System[25,26] established in 1988 in Takashima County (City), Shiga, Japan. The objective of this disease registration system was to measure trends in the incidence and case fatality of stroke, and to compare these with data from inside and outside of Japan. Takashima City is located in the central part of Japan, in Shiga prefecture, which is bounded to the east by the Biwako lake and the Hira mountain range to the west. The weather in Takashima follows 4 seasons: winter, spring, summer and autumn.

Population Characteristics of the Registration Area

The inhabitants of Takashima City have a similar standard of living. There was a total of 52,440 inhabitants (men, 48.7 %; women, 51.3 %) in the year 2010. Of the population, 27.9% were aged ≥65 years, which is higher than the all-Japan proportion of 22.5%.[27] The population data were collected from the 2010 population census of Shiga prefecture by age (5-year-old class), by sex (total age, average age and foreigners), and by towns.[28]

Case Finding and Registration Process

In brief, the Takashima Stroke Registry is an ongoing population-based registry study designed to build a complete information system regarding all cases of acute ischemic and non-traumatic cerebral hemorrhage among residents of Takashima City. All stroke patients who were the residents of Takashima City and visited hospitals in the Kosei medical administration area or the 4 major emergency hospitals located in the neighboring medical administration areas were included in the registry. Approval for this study regarding ethical issues was obtained from the Institutional Review Board of the Shiga University of Medical Science (R2000-014).

Diagnostic Criteria and Items Registered

Stroke was defined as sudden onset of focal neurological symptoms that continued for a minimum of 24 h or resulted in death according to the Monitoring of Trends and Determinants in Cardiovascular Disease (WHO-MONICA) projects,[29] and the Monitoring System for Cardiovascular Disease, commissioned by the Ministry of health and welfare, Japan.[26] Diagnosis of stroke type was based on clinical symptoms as well as neurological imaging by computed tomography (CT) or magnetic resonance imaging (MRI). In the registered stroke cases, the diagnosis was verified by neurological imaging in 93.6% of cases. Of these, 50% had CT alone, 39% had both CT and MRI, and 5% had MRI alone. Stroke was classified as ischemic stroke, cerebral hemorrhage, subarachnoid hemorrhage, and unclassified. In the registration, items recorded were the date and time of stroke onset and hospital admission, the extent of neurological involvement and clinical records of previous history, family history, management given, blood-biochemical parameters on admission, rehabilitation, death, cause of death, recurrence, neurological imaging observations, etc. Details of the case findings, registration procedure, diagnostic criteria, and registered variables have been described in a previous study.[24]

Meteorological Data

Data on temperature variables were obtained from the nearest observatory of the Japan Meteorological Agency. The temperature parameters were acquired from daily measurements at the Imazu weather station located in Imazu-cho in Takashima City, including daily average temperature, minimum temperature and maximum temperature. All data acquisition was based on Japan Meteorological Agency policies.

Statistical Analysis

Only confirmed cases of first-ever stroke were included in our study. We excluded 757 participants with missing information of the onset date, date of birth, doubtful cases of stroke type and the recurrence of stroke. We also excluded extreme age ≥110 years (n=1). The time period of the study was from January 1, 1988 to December 31, 2010.

A comparative database of registry information of stroke onset day, diagnosis of type-specific stroke, sex, date of birth, information of recurrence and risk factors was created. The population demographic data derived from the routine census and vital statistics system were collected annually for Takashima City for each of the years of study period as 5-year age group, number of men and women of the age group was imported into the database. The temperature data of average temperature, minimum temperature and maximum temperature of each day incorporated with the database by date.

Descriptive statistics on participants and temperature parameters are presented as percentages for categorical variables and as mean (SD) or median (interquartile range) for continuous variables. Crude incidence rates (IR) of type-specific stroke per 100,000 person-years, including 95% confidence intervals (CI), were estimated in each quintile of average, minimum and maximum temperatures.

Relationships between daily temperature parameters and the incidence rate ratio (IRR) of stroke and subtypes were assessed by Poisson regression analysis controlling for age and sex. The IRR with corresponding 95% CI were calculated for lower and higher quintiles (Q1, Q2, Q4, Q5) of the daily average, minimum, and maximum temperatures, compared with the middle quintile (Q3) as reference. We presumed that Q3 is representative of the comfortable temperature range in Takashima City. We also calculated the age- (<65 and ≥65 years) and sex-stratified analysis of stroke and subtypes. In addition, a season-stratified analysis to examine the association between quintiles of temperature parameters and incidence of stroke and subtypes was performed. We defined the 4 seasons as winter (December–February), spring (March–May), summer (June–August), and autumn (September–November). An additional analysis to examine the effect of lag period exposure of the mean of onset day and 1–5 days prior temperature were assessed for all stroke.

A P value <0.05 was considered statistically significant. All relevant data analyses were performed using SAS 9.4 software (SAS Institute Inc., Cary, NC, USA).

Results

Table 1 shows the clinical characteristics of the registered cases of first-ever stroke, from 1988 to 2010. During this period, a total of 2,405 (men, 1,294; women, 1,111) confirmed stroke cases were registered in Takashima City. The mean age for men and women was 69.6±11.7 years and 75.4±11.6 years, respectively. Among the patients, 1,836 (76.3%) were ≥65 years old. Stroke cases were classified as ischemic stroke (n=1,625; men, 942; women, 683), cerebral hemorrhage (n=545; men, 261; women, 284) and subarachnoid hemorrhage (n=213; men, 77; women, 136). There were a few unclassified strokes (22 cases; <1%).

Table 2 shows the daily temperatures of Takashima City; the mean of average temperature was ≈14.0°C, ranging from −2.5°C to 30.1°C, minimum temperature was 10.3°C [range, −8.5°C to 26.8°C] and maximum temperature 17.9°C [range, −1.4°C to 36.9°C].

Table 3 shows the crude IRs of all stroke and subtypes across the quintiles of daily average temperature. Incidence of stroke and subtypes was highest in the middle quintile. IRs in the minimum and maximum temperatures included in **Supplementary Table 1** show similar results for all stroke.

Table 4 presents the IRR of stroke and subtypes for quintiles of average, minimum and maximum temperatures adjusted for age and sex, using the middle quintile as a reference. For all stroke, IRR was significantly lower in the highest and second-highest quintiles of average temperature (Q5: 0.81, 95% CI 0.71–0.92; Q4: 0.80, 95% CI 0.71–0.91). The association prevailed in the minimum and maximum temperatures. In the type-specific analysis, IRR

Table 1. Characteristics of Cases of First-Ever Stroke in Takashima Stroke Registry, Japan From 1988 to 2010

Characteristics	Stroke
N	2,405
Men	1,294 (53.8%)
Mean age for men, years	69.6 (11.7)
Women	1,111 (46.2%)
Mean age for women, years	75.4 (11.6)
Age	
<65 years	569 (23.7%)
≥65 years	1,836 (76.3%)
Stroke subtype	
Ischemic stroke	1,625 (67.6%)
Cerebral hemorrhage	545 (22.7%)
Subarachnoid hemorrhage	213 (8.9%)
Unclassified stroke	22 (0.9%)
Risk factors	
Hypertension	1,378 (57.3%)
Diabetes	448 (18.6%)
Dyslipidemia	408 (17.0%)
Chronic kidney disease	130 (5.4%)
Smoking	
Current	562 (23.4%)
Non-smoker	1,106 (46.0%)
Past smoker	85 (3.5%)
Unknown	652 (27.1%)
Drinking	
Current	545 (22.7%)
Non-drinker	1,312 (54.6%)
Past drinker	30 (1.2%)
Unknown	518 (21.5%)

Values represent numbers of patients (percentage) or mean ± SD, as appropriate.

Table 2. Temperature Parameters in the Study Area

Parameter	Mean±SD	Min.	Percentile			Max.	IQR
			25th	50th	75th		
Average temperature	14.0±8.5	−2.5	6.2	14.2	21.5	30.1	15.3
Minimum temperature	10.3±8.6	−8.5	2.1	10.0	18.3	26.8	16.2
Maximum temperature	17.9±8.8	−1.4	10.0	18.4	25.3	36.9	15.3

All temperature units are in degrees Celsius. IQR, interquartile range; Min, minimum; Max, maximum; SD, standard deviation.

Table 3. Incidence Rate of Stroke (First-Ever) and Its Subtypes (per 100,000 Person-Years) in Daily Average Temperature, Takashima Stroke Registry, Japan, 1988–2010

	IR (95% CI)	IR (95% CI)	IR (95% CI)	IR (95% CI)	IR (95% CI)
Average temperature	Q1 (−2.5, 4.8)	Q2 (4.9, 10.6)	Q3 (10.7, 17.2)	Q4 (17.3, 22.9)	Q5 (23.0, 30.1)
All stroke	326.3 (298.7–356.4)	326.8 (299.4–356.9)	357.3 (328.4–388.8)	286.8 (261.1–315.1)	292.4 (266.6–320.8)
Ischemic stroke	223.0 (200.1–248.2)	212.8 (190.9–237.3)	237.1 (213.8–263.0)	189.7 (169.0–212.9)	211.3 (189.5–235.6)
Cerebral hemorrhage	71.2 (59.0–86.1)	78.4 (65.5–93.8)	85.0 (71.5–101.1)	66.1 (54.3–80.4)	59.5 (48.5–73.1)
Subarachnoid hemorrhage	30.0 (22.4–40.1)	31.0 (23.3–41.2)	31.2 (23.5–41.5)	28.4 (20.1–38.3)	20.5 (18.4–28.9)

All temperature units are in degrees Celsius. IR, crude incidence rate of stroke per 100,000 person-years; Q1, Q2, Q3, Q4, Q5=quintiles of average temperature parameter; CI, confidence interval.

Table 4. Association of Temperature Parameters of the Day With the Incidence Risk of Stroke, Takashima Stroke Registry, Japan, 1988–2010

	IRR (95% CI)	IRR (95% CI)	(Reference)	IRR (95% CI)	IRR (95% CI)
Average temperature	**Q1 (−2.5, 4.8)**	**Q2 (4.9, 10.6)**	**Q3 (10.7, 17.2)**	**Q4 (17.3, 22.9)**	**Q5 (23.0, 30.1)**
All stroke	0.91 (0.81–1.03)	0.91 (0.81–1.03)	1	0.80 (0.71–0.91)*	0.81 (0.71–0.92)*
Ischemic stroke	0.94 (0.81–1.09)	0.89 (0.77–1.04)	1	0.80 (0.69–0.94)*	0.88 (0.76–1.02)
Cerebral hemorrhage	0.84 (0.65–1.08)	0.92 (0.72–1.18)	1	0.78 (0.60–1.01)	0.69 (0.53–0.91)*
Subarachnoid hemorrhage	0.96 (0.64–1.44)	0.99 (0.66–1.48)	1	0.91 (0.60–1.38)	0.65 (0.41–1.02)
Minimum temperature	**Q1 (−8.5, 1.0)**	**Q2 (1.1, 6.3)**	**Q3 (6.4, 13.2)**	**Q4 (13.3, 19.7)**	**Q5 (19.8, 26.8)**
All stroke	0.97 (0.86–1.10)	0.93 (0.82–1.05)	1	0.82 (0.72–0.93)*	0.86 (0.75–0.97)*
Ischemic stroke	1.02 (0.88–1.18)	0.89 (0.76–1.03)	1	0.82 (0.70–0.96)*	0.93 (0.80–1.08)
Cerebral hemorrhage	0.91 (0.70–1.18)	1.01 (0.78–1.30)	1	0.83 (0.64–1.08)	0.79 (0.60–1.03)
Subarachnoid hemorrhage	0.85 (0.57–1.28)	1.01 (0.68–1.49)	1	0.78 (0.51–1.19)	0.61 (0.39–0.96)*
Maximum temperature	**Q1 (−1.4, 8.6)**	**Q2 (8.7, 14.9)**	**Q3 (15.0, 21.3)**	**Q4 (21.4, 26.6)**	**Q5 (26.7, 36.9)**
All stroke	0.94 (0.83–1.06)	0.91 (0.81–1.03)	1	0.81 (0.72–0.92)*	0.81 (0.72–0.92)*
Ischemic stroke	0.94 (0.81–1.09)	0.90 (0.77–1.04)	1	0.79 (0.67–0.92)*	0.89 (0.76–1.03)
Cerebral hemorrhage	0.97 (0.75–1.25)	0.93 (0.72–1.21)	1	0.86 (0.66–1.12)	0.72 (0.55–0.94)*
Subarachnoid hemorrhage	0.90 (0.59–1.35)	0.98 (0.66–1.46)	1	0.93 (0.62–1.40)	0.58 (0.37–0.92)*

All temperature parameters in degrees Celsius; Q1, Q2, Q3, Q4, Q5=quintiles of corresponding daily temperature parameter; Q3=reference middle quintile. *P<0.05. IRR, incidence rate ratio estimated from age and sex adjusted Poisson regression analysis. Other abbreviations as in Table 3.

in the second-highest quintile was significantly lower (Q4: 0.80, 95% CI 0.69–0.94) for ischemic stroke. This association prevailed through the minimum and maximum temperatures. For cerebral hemorrhage, in the average and maximum temperatures, the IRR in the highest quintile was significantly lower (Q5: 0.69, 95% CI 0.53–0.91; 0.72, 95% CI 0.55–0.94, respectively). Subarachnoid hemorrhage in the highest quintile was significantly lower in the minimum and maximum temperatures (Q5: 0.61, 95% CI 0.39–0.96; 0.58, 95% CI 0.37–0.92, respectively).

Supplementary Table 2 shows the age- (<65 and ≥65 years) and sex-stratified stroke events by type. In the younger age group, there were more men for all stroke.

Supplementary Table 3 shows the IRR of stroke in the <65 and ≥65 years age groups adjusted for sex. The younger age group did not show significant results, whereas the ≥65 years age group showed an analogous association observed for all stroke and ischemic stroke in all 3 temperature parameters in the main analysis (**Table 4**).

We additionally analyzed the sex-stratified analysis controlling for age, which showed that increasing temperature was protective for all stroke in the average and minimum temperatures for men, and for women in the average and maximum temperatures (**Supplementary Table 4**). However, we also observed an association of lower average temperature for all stroke and lowest quintile of minimum temperature for subarachnoid hemorrhage in men, which was protective.

Supplementary Table 5 shows that the mean of lag period temperature parameters and the association with all stroke. The results of this additional analysis tended to agree with our main results (**Table 4**).

Supplementary Table 6 presents the association of the temperature parameters of the days of the season with the incidence risk for all stroke. Results showed that increasing maximum temperature in spring was protective for all stroke.

Discussion

The present study demonstrated a relationship between daily ambient temperature parameters and the incidence of stroke including its types. Our results suggested that an increase in the daily temperature, irrespective of the parameters, average, minimum, and maximum temperature were associated with a protective effect for all stroke. This association was also observed for ischemic stroke, in particular, even in individuals aged ≥65 years. A similar pattern of association prevailed with cerebral hemorrhage in the average and maximum temperatures, whereas increasing minimum and maximum temperatures may safeguard individuals against subarachnoid stroke.

Assessing the relationship between ambient temperature and stroke in Japan, a good number of studies have dealt with only 1 particular subtype of stroke.[19,21,22] A population study[23] used annual data of temperature of a town on stroke incidence, but the age of participants was limited to 40–69 years, by which means a good number of community dwellers were excluded, as life expectancy in Japan is higher. Our present study covered almost all community dwellers at risk. To the best of our knowledge, the current study is the first of its kind to assess the incidence risk of stroke by type and daily ambient average, minimum and maximum temperatures in Japan. Moreover, our data were obtained from a relatively new and large-scale population-based registry.

The association of daily ambient temperature with stroke onset or hospital admission has shown a U-, V-, or J- shaped association in previous studies in different geographical regions.[30–33] Vulnerability of aged people to ambient temperature is also known.[10,34] The results of the current study showed that warmer ambient average, minimum, and maximum temperatures may have a protective effect on stroke even for the ≥65 years age group. Our results are in line with some previous studies in Japan[15,16,21] and elsewhere.[14] A population-based study in Japan,[16] where the monthly mean ambient temperature was examined in addition to the seasonality of stroke incidence, showed similar results of our current study. The authors reported that stroke incidence was negatively correlated with cerebral hemorrhage and cerebral infarction. Our study results corroborate the protective effect observed for subarachnoid hemorrhage in the highest quintiles of minimum and maximum temperatures, which denote the warmer seasons. By virtue of a population-based registry, we were able to conduct an analysis of daily ambient temperature using a larger number of stroke events to derive a precise picture, particularly when we consider all 3 temperature parameters.

The association between low mean ambient temperature and intracerebral hemorrhage[35] and all stroke[36] was reported in recent meta-analyses. Our study did not find any significance in the stroke incidence risk in the lower quintiles of any of temperature parameters. This finding may be related to the difference of the temperature parameters between other study areas and Takashima. Also, acclimatization of participants with the weather and the advancement of modern housing and air-conditioning systems may play a role. Moreover, absence of an association in cerebral hemorrhage incidence risk in the lower quintiles may be related to the decreasing trend in systolic blood pressure and also the decreasing prevalence of severe hypertension among the Japanese population.[37]

Blood pressure is a major risk factor for stroke. Previous studies concluded that blood pressure increase in cold weather and decreases in warm weather.[38] It is speculated that sympathetic activation elevates both systolic and diastolic blood pressure,[39] and the morning blood pressure surge on cold days,[40] and both blood pressure and the morning blood pressure surge are low on hot days.[41] Also, the renin-angiotensin system is activated by cold to increase blood pressure.[42] A previous study reported that in aging populations cardiac autonomic function is inversely associated with higher ambient temperatures with heart rate variability in warm seasons.[43] The authors of a study of cardiovascular mortality in Taiwan speculated that the decrease in mortality from cerebral hemorrhage may be related to decreased blood pressure at higher temperatures.[34]

The mechanism of the protective effect of warmer temperature on strokes is not fully understood. The physiological response of the body to temperature may be a potential risk factor for stroke incidence.[15,44] Also, fluctuation in temperature contributes to epidemics of influenza and other lower respiratory tract infections,[45,46] causing a hypercoagulable state, and the risk of atherosclerotic plaque rupture[47] in colder temperatures contributes to cerebral thrombosis. The variation of biological factors in warmer temperatures, such as the plasma fibrinogen level, blood viscosity, and lipid profile, may play a protective role from atherosclerosis.[15,48,49] It might also contribute to the protective effect of warmer weather for stroke incidence observed in the current study.

Age- and sex-stratified analyses to examine the association between ambient temperature and stroke in subpopulations are reported in previous studies.[35,50] Elderly populations have increased hospitalization rates as the temperature decreases.[38,51] Our study result remained significant in the ≥65 year age group population in line with a recent meta-analysis.[52] The significant association of men in the lower quintiles of average temperature for all stroke may be related to the mean of average temperature range in the study area (14.0, SD: 8.5). However, the protective effect of the minimum temperature for subarachnoid hemorrhage is in contrast to a previous study.[19]

The association of the lag period effect of temperature parameters on stroke incidence or mortality has found in previous studies.[53,54] Additional analysis of our study data showed that the incidence risk of all stroke was significantly associated with the higher quintiles of the onset day to 1–5 days' prior mean of corresponding temperature parameters, which is homologous to the main result (**Table 4**).

Seasonality has been observed in stroke incidence in Japan in previous studies.[15–17,55] Our study result of seasonality was significant in the maximum temperature, which may be related to the largest temperature variation in spring. This increasing temperature may have a protective role on the stroke incidence risk for all stroke, which was consistent with our main result.

For the current study, the data were obtained from a registry (i.e., surveillance data based on a community), so the causal relationship between ambient temperature and stroke could not be explored directly. However, the effect of temperature could be related to duration of exposure to the outside temperature and air-conditioning of the home, which could be a further study.

The quality of the registry data was ensured by capturing all cases of first-ever stroke in the study area by covering all the local hospitals, which have occupancy rates >98%,[24] and 3 medical referral centers outside Takashima City. As the Japanese population is covered by health insurance, people visit the local hospital and are assessed by physicians, then referred to higher center for further evaluation, where they are further investigated with MRI or CT scan. So, it could be assumed that most community dwellers were covered by this registry and the stroke and its subtypes were diagnosed accurately.

Our study has several strengths. Data were obtained from a population-based registry in an area where the temperature difference in summer and winter shows a wide variation. Therefore, the physiological and biological adaptability to extreme of cold and hot weather prevailed in the population. Previous studies show that people have better adaptation to the ambient temperatures of the region where they live.[53] So, our study is unique for fulfilling the need for locality-specific data for understanding the effect of ambient temperature on stroke occurrence. We also analyzed the incidence of type-specific stroke. Most strokes were diagnosed using CT and/or MRI (>93%), which added strength to the research. Moreover, we considered the appearance of symptoms as the event day rather than the day of hospitalization, which prevented the null bias.

Study Limitations

The Imazu weather station data did not include the atmospheric pressure and humidity, so we did not measure their effect on stroke in the current study. Also, factors such as duration of exposure to the outside temperature are not possible to adjust, together with air-conditioning and heating systems. Another limitation that we did not consider was the effect of air pollution, which has been found to be a risk factor of ischemic stroke. A further limitation is that the Takashima Stroke Registry covers a semi-urban and rural population in central Japan, so it is the results may not be generalizable for the whole of Japan.

Conclusions

Available data from the Takashima Stroke Registry demonstrated that an increase in temperature, irrespective of the parameter being measured (average, minimum, or maximum), had a protective effect against stroke incidence, particularly for age ≥65 years. Importantly, further research will be helpful to find the extent and nature of the relationship between stroke incidence and temperature parameters under different demographic and geographic variations.

Conflicts of Interest

All authors declare no conflicts of interest.

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IRB Information

Approval for this study regarding ethical issues was obtained from the Institutional Review Board of the Shiga University of Medical Science (R2000-014).

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Supplementary Files

Please find supplementary file(s);
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