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Long-term temperature variability and death among stroke patients: A cohort study in central Shandong province, China

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A R T I C L E I N F O

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A B S T R A C T

Our current understanding of the repercussions stemming from long-term temperature variability (TV) within the broader context of global climate change remains considerably limited. This study aims to investigate the influence of long-term temperature variability on the probability of death and mortality among stroke patients. For this study, a sample of stroke patients aged 40 years and above between 2016 and 2019 was taken from five districts/counties in central Shandong Province. We calculated the standard deviation (SD) of the annual mean daily temperature and the annual mean diurnal temperature range (DTR) obtained from the baseline survey to express the long-term TV. To assess the link between TV exposure and mortality among stroke patients, we utilized the Cox proportional hazards regression method. This statistical method allowed us to estimate the adjusted hazard ratio (HR) and 95 % confidence interval (CI) with regard to the risk of mortality. For stroke patients, there was a correlation between a 1 °C rise in the SD of temperature and an elevated risk of mortality (HR: 1.18, 95 % CI: 1.08–1.29). Additionally, each 1 °C increase in the DTR was associated with a further increase in the risk of death (HR: 1.69, 95 % CI: 1.59–1.79). In patients diagnosed with ischemic and hemorrhagic stroke, DTR was found to be positively associated with the risk of death. Temperature SD was found to be positively associated with the risk of death only in patients with ischemic stroke. Persistent exposure to TV was strongly linked to mortality risk among individuals with stroke. By devoting increased attention to TV, these organizations can develop strategies to mitigate its adverse effects on public health.

1. Introduction

Stroke represents a major and pressing global health challenge, standing prominently among the leading contributors to both mortality and disease on a truly international level. Findings from the comprehensive Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) conducted in 2017 underscored the gravity of stroke's impact, revealing its position as the second leading cause of global mortality during that specific year [1,2]. Despite improvements in medical care, the absolute number of stroke cases has risen dramatically, presenting a major global public health challenge [3–5]. Multiple factors contribute to the development of stroke, including environmental factors, behavioral factors, and abnormal metabolic factors [6]. The GBD conducted in 2019 emphasized an important finding: nonoptimal temperature accounted for a substantial portion, specifically 37 %, of the disability-adjusted life years lost as a result of stroke-related causes [3]. This underscores the substantial burden associated with temperature-related factors in stroke outcomes. Given the increasing concern about environmental change, understanding the impact of environmental factors, including temperature variability (TV), on stroke

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mortality is crucial [7].

Long-term TV is expected to increase substantially due to global warming [8,9]. Despite a proven link between the average daily temperature and disease mortality, TV is underutilized as an indicator of climate change [10,11]. Temperature changes have been associated with physiological alterations, including changes in lipid levels (especially cholesterol), blood glucose, serum fibrinogen concentration, impaired endothelial function, and peripheral vasculature dysfunction. These changes can impose an additional burden on the cardiovascular system, potentially triggering strokes [12–14]. A growing body of epidemiological research suggests that exposure to TV for short periods of time is related to an elevated risk of stroke-related death and hospitalization [15–17]. Hence, TV appears to assume a new role as a potential risk factor for strokes based on the accumulating evidence from various studies. Long-term TV focuses on long-term trend changes in temperature parameters, usually over time scales of years, decades, centuries, or even millennia [18]. Short-term TV focuses more on changes in weather phenomena and weather systems, such as heat waves, cold snaps, etc., usually referring to changes in temperature conditions over days, weeks, or even months [19]. Unlike adaptation to usual temperatures, individuals may not adapt as effectively to long-term changes in temperature [13,20]. Research exploring the influence of long-term TV on death rates among stroke patients is limited, although there have been studies examining, its effects on mortality related to cardiovascular disease [21]. Gathering additional evidence is imperative to gauge the role of prolonged TV on stroke, considering the heightened vulnerability of stroke to fluctuations in weather conditions [22,23]. With the inevitable rise in global temperatures [24] and the potential increase in stroke-related deaths due to climate change, understanding the relationship between long-term TV and stroke is paramount. For countries to avoid becoming vulnerable to TV in the future, it is necessary to prioritize the development of effective adaptation and mitigation strategies that will reduce the vulnerability of populations to TV while simultaneously protecting global health. Additional evidence is necessary to guide policy-making and interventions aimed at safeguarding individuals worldwide from the detrimental health effects of long-term TV.

With four distinct seasons, Shandong Province boasts a warm temperate monsoon climate. We looked at five districts located in central Shandong Province to understand what long-term TV does to the risk of death among stroke patients. We aimed to provide valuable evidence on the potential influence of long-term TV on stroke patient-related mortality in this region. The outcomes of our study will contribute to an enhanced comprehension of how climatic factors affect the mortality risk among stroke patients in the context of a developing country.

2. Methods

2.1. Study participants

In Shandong, the central region covers the largest area and is also the political, cultural, and historical center of the province. Relying on the chronic disease morbidity and mortality surveillance system of the Shandong Provincial Center for Disease Control and Prevention (CDC), stroke cases from 2016 to 2019 in five districts/counties in central Shandong Province were sampled. Then, firstly, patients with permanent address change, missing information, duplicate information, recurrence and death on the day of onset were excluded, and secondly, on this basis, stroke patients aged ≥40 years were selected, and finally, 35,691 stroke patients were included. Upon the death of a patient, hospital doctors in China promptly fill out death certificates, which are then transmitted electronically to the CDC. This electronic transmission process enhances accuracy and ensures the timely submission of the certificates.

2.2. Study design, data source, and setting

This study was conducted with a follow-up period from January 1, 2016–December 31, 2019, with endpoints of death due to stroke (International Classification of Diseases 10th Revision (ICD-10) codes *I60–I63*), end of follow-up, or death due to other causes in the surveillance system. The causes of stroke among patients were divided into ischemic stroke and hemorrhagic stroke. Crucial baseline data on stroke patients, including sex, age, usual address, time of onset, time of death, cause of onset, and cause of death, were provided by the Shandong Provincial Center for Disease Control and Prevention. The patients were further classified into urban and rural areas divided into address classifications by the National Bureau of Statistics.

2.3. Exposure

Temperature datasets acquired by the National Weather Center have been widely used in previous studies. For this study, the National Weather Center provided the daily average ambient temperatures from 2013 to 2019. Renowned as one of China's most comprehensive climate datasets, it boasts a spatial resolution of $0.25^\circ \times 0.25^\circ$ and a temporal resolution of 3 h [25]. The location of each study subject at the village/community level, which was determined by latitude and longitude on a map, was obtained, and then the average daily temperature exposure was matched to each study subject. In assessing the link between weather instability and population health, two key indices are commonly utilized: intraday TV, exemplified by the diurnal temperature range (DTR), and interday TV, represented by the standard deviation (SD) of daily mean temperature. These indicators have a key role in terms of understanding the relationship between weather fluctuations and their impact on human well-being [16,20,26]. To enhance the accuracy of assessing the relationship between TV and population health, it is crucial to consider both intraday and interday variability. As the unstable climate is a continuum, the inclusion of these two aspects allows for a more holistic approach to assessing the link between TV and population health [27]. The SD of the mean daily temperature for the baseline survey year and the mean DTR for the baseline survey year were used to represent the long-term TV calculations [18]. Assigning weather data for each stroke patient was accomplished by utilizing the survey dates in the residential area at baseline.

2.4. Covariate measurements

After employing revised estimation methods and utilizing directed acyclic graphs to select confounders, the following potential confounding factors were taken into consideration (Fig. S1): sex (male and female), age, urbanity (urban and rural), average annual particulate matter with a diameter ≤2.5 μm ($PM_{2.5}$), relative humidity, average annual rainfall, and average annual ozone (O_3). This was in line with previous studies [28–32].

ChinaHighAirPollutants (CHAP) (https://weijing-rs.github.io/product.html) provided daily $PM_{2.5}$ and O_3 data from 2016 to 2019. The dataset is based on spatiotemporal predictors such as satellite remote sensing, meteorological factors, and land use information, and spatiotemporal estimation models for $PM_{2.5}$ with a spatial resolution of 1 km^2 and O_3 with a resolution of 0.1° (≈10 km) were developed [50,51]. The dataset is continuously updated to provide more comprehensive and accurate air pollution data by increasing pollutant concentration data types, spatial and temporal resolution, and spatial and temporal coverage. This dataset is currently published by the National Earth System Science Data Center (http://www.geodata.cn/). We also obtained daily relative humidity data from the National Weather Center for 2016–2019 and daily rainfall data from the Science Data Bank. These data were calculated as annual means and were all matched to each stroke patient by the same method as described above for ambient temperature.

2.5. Statistical analysis

For our study, we adopted a consistent approach for reporting variable types. Continuous variables that followed a normal distribution are presented as the means ± SDs. In contrast, continuous variables that deviated from a normal distribution are expressed as medians (quartiles). Categorical variables, on the other hand, are reported as frequencies accompanied by the corresponding composition ratios.

By employing Cox proportional hazards models, we investigated the relationship between long-term TV and the risk of stroke-related mortality. The Cox proportional risk regression model, is a semiparametric regression model proposed by the British statistician D.R. Cox (1972) year. The model takes survival outcome and survival time as dependent variables, can analyze the effects of many factors on survival at the same time, can analyze information with truncated survival time, and does not require the estimation of the type of survival distribution of the information. The basic form of the model is:

$$h\ (t,\ X) = h_0(t)\ \exp\ (\beta_1X_1+\beta_2X_2+\ +\beta_m\ X_m).$$

Where $\beta_1,\beta_{2,\ \ldots,}\beta_m$ is the partial regression coefficient of the independent variable, which is the parameter to be estimated from the sample data, and $h_0(t)$ is the baseline hazard rate of h (t, X) when the X vector is 0, which is the quantity to be estimated from the sample data.

Through this analysis, we were able to estimate the hazard ratio (HR) for each association, accompanied by the corresponding 95 % confidence interval (CI). We also studied the risk of death among stroke patients from different causes associated with long-term TV. In general medical research, we usually analyze the relationship between independent and dependent variables by constructing regression models. However, most regression models have an important assumption condition: the independent variable and the dependent variable are linearly related. This condition is generally difficult to fulfill. If there is a nonlinear relationship between the independent and dependent variables, a common method is to plot a restricted cubic spline (RCS). The goal of using RCS is to present nonlinear relationships in a way that is visually appealing and accurately represents the relationships in the data while avoiding over-fitting and improving the interpretability of the graphs. We used an RCS with three degrees of freedom and used television as a continuous variable to further analyze the data. We also categorized stroke patients according to the degree of urbanity (urban and rural) and explored the association between their mortality rates and long-term temperature variability (temperature SD and DTR) by RCS, respectively. Utilizing this model, we calculated the HR and the corresponding 95 % CI for individuals exposed to the median TV level [33].

To identify the most vulnerable subgroups, we evaluated effect modification by sex (female vs. male), age (≥65 vs. <65 y), and urbanity (urban and rural) in Cox models, by including interaction terms between these potential effect modifiers and TV. This allowed us to investigate whether these factors influenced the observed relationship. With regard to the lagged effect of ambient temperature on disease [33], we examined the relationship between ambient temperature and stroke mortality by incorporating TV metrics that lagged exposure by 2, 3, and 4 years. Specifically, we calculated lagged TV indicators, including the SD and DTR, which represented the variability in mean temperature and diurnal temperature range, respectively, over the baseline survey year and the previous 1, 2, and 3 years. Furthermore, we constructed three additional models as sensitivity analyses, tested model robustness by adding or subtracting covariates. The test was designed to determine whether the significant effects of temperature variability and death in stroke patients remained stable even when certain covariates were not taken into account. Model 1 incorporated O_3 into the main model, while Model 2 excluded $PM_{2.5}$ and O_3 from Model 1. Finally, Model 3 excluded $PM_{2.5}$, O_3, relative humidity, and average annual rainfall from the main model.

3. Results

3.1. Summary statistics

Fig. 1 illustrates the distribution of the selected regions for the 35,691 participants included in the final analysis. We summarized the basic characteristics of the population studied. During the follow-up period, we recorded 1277 patient deaths due to ischemic stroke and 2761 patient deaths due to hemorrhagic stroke. The participants were 52.4 % male, with an average age of 66.98 years. The percentage of women is 47.6 % and the average age is 68.32 years. The mean SD of temperature was 10.37 °C, and the mean DTR was 10.36 °C (Table S1).

3.2. Main analytical results

Adjusting for confounding factors, our analysis demonstrated a positive correlation between long-term TV and mortality risk among stroke patients. A positive association was found between long-term TV and the risk of death after ischemic stroke, while a positive association was found between the DTR and the risk of death after hemorrhagic stroke (Table 1). There was an 18 % (HR: 1.18, 95 % CI: 1.08–1.30) increase in the death risk for every 1 °C increase in the SD of temperature and a 69 % increase in the death risk for each 1 °C increase in the DTR among stroke patients. Regarding the risk of death among patients with ischemic stroke, there was a significant correlation of an HR of 1.18 per 1 °C increase in the SD of temperature and an HR of 1.67 per 1 °C increase in the DTR. The risk of death among patients with hemorrhagic stroke was also positively associated with the DTR, with a 1 °C increase in the DTR associated with a 1.51-fold increase in the risk of death among patients with hemorrhagic stroke.

Nonlinear associations were observed between long-term exposure to the SD of temperature (Fig. 2) and the DTR (Fig. 3) and the risk of death among stroke patients, as indicated by restricted cubic spline models. Thresholds exist in Fig. 2, showing an upward trend between 9.50 and 10.47 and a downward trend after 10.47. Fig. 3 does not have a threshold and always shows an upward trend. And the restricted cubic spline plots also showed that the mortality rate of stroke patients, both rural and urban, showed a nonlinear relationship with the temperature SD, which increased and then decreased; and with the DTR, which continued to increase (Fig. 4). Statistical tests confirmed this nonlinear relationship, with P values less than 0.01.

3.3. Stratified analysis results

As shown in Table S2, the results were similar for the subgroups of the stratified analysis, except for those in the age≤65 group, which was affected by the standard deviation of temperature, and those in the living in the city group, which was affected by the standard deviation of temperature. The findings indicated a positive association between long-term exposure to TV, including both the SD of temperature and the DTR, and the risk of death among stroke patients. Furthermore, there were variations in the impact of the long-term DTR across different age groups ($P < 0.05$).

3.4. Sensitivity analysis

3.4.1. Results of lag effect analysis

In sensitivity analyses, long-term TV was significantly associated with an increased risk of death in stroke patients. The risk of death in stroke patients increased by 2.53, 1.55, and 3.00 for every 1 °C increase in the temperature SD at lag 02, lag 03, and lag 04 years, respectively; and the risk of death in stroke patients increased by 3.03, 4.12, and 4.76 for every 1 °C increase in the DTR at lag 02, lag 03, and lag 04 years, respectively. We calculated lagged TV indicators, including the SD and DTR, which represented the variability in mean temperature and diurnal temperature range, respectively, over the baseline survey year and the

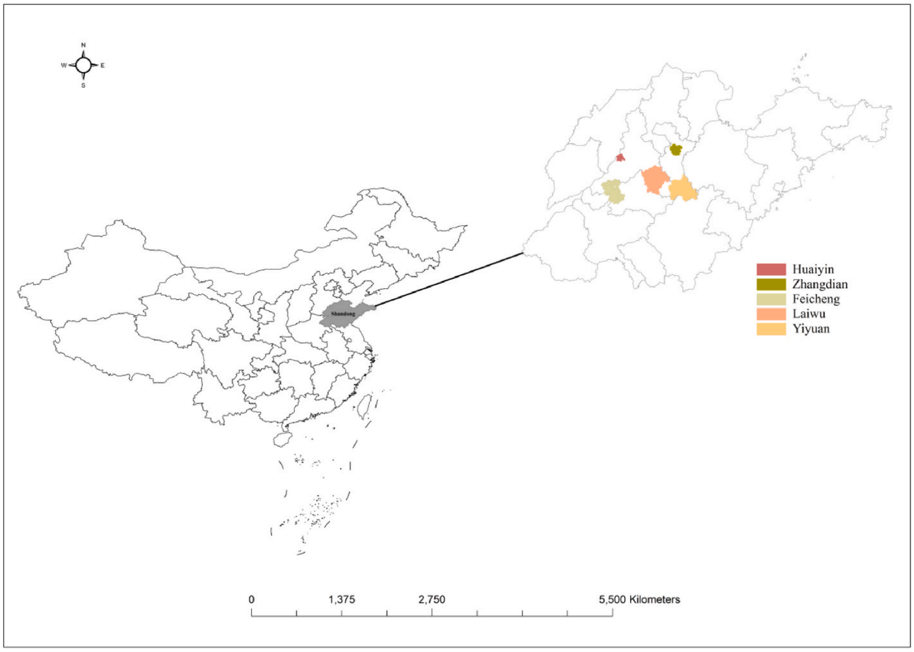

Fig. 1. Shandong Province five survey area distribution.

Table 1
Hazard Ratio and 95 % confidence intervals for long-term temperature variability on the death in stroke patients.

Case fatality	Main model
Temperature Standard Deviation	
Stroke	
No. Of events	4308
Person-years	1983.31
HR (95%CI)	1.18 (1.08,1.29)
Ischemic stroke	
No. Of events	2761
Person-years	1692.10
HR (95%CI)	1.18 (1.05,1.31)
Hemorrhagic stroke	
No. Of events	1277
Person-years	291.21
HR (95%CI)	1.14 (0.95,1.35)
Diurnal Temperature Range	
Stroke	
No. Of events	4308
Person-years	1983.31
HR (95%CI)	1.69 (1.59,1.79)
Ischemic stroke	
No. Of events	2761
Person-years	1692.10
HR (95%CI)	1.67 (1.57,1.81)
Hemorrhagic stroke	
No. Of events	1277
Person-years	291.21
HR (95%CI)	1.51 (1.34,1.71)

HR, Hazard Ratio; 95 % CI, 95 % confidence intervals; The HRs (95 % CIs) of the main model were the results after adjustment of sex, age, mean annual $PM_{2.5}$ concentration, relative humidity, and mean annual rainfall.

previous 1, 2, and 3 years.

3.4.2. Model robustness results

By adding or subtracting certain covariates, we found that the positive association of long-term TV with the risk of death in stroke patients remained significant. Model 1, which included O_3 in the main model, had temperature SD to stroke patient mortality risk ratio of 1.17 (1.07, 1.27), and DTR to stroke patient mortality risk ratio of 1.55 (1.48, 1.62); model 2, which excluded $PM_{2.5}$ and O_3 from model 1, had temperature SD to stroke patient mortality risk ratio of 1.31 (1.20, 1.43), and the ratio of DTR to the risk of death in stroke patients was 1.63 (1.55, 1.71); finally, Model 3 excluded $PM_{2.5}$, O_3, relative humidity, and mean annual rainfall from the main model, and the ratio of temperature SD to the risk of death in stroke patients was 1.10 (1.01, 1.22), and the ratio of DTR to the risk of death in stroke patients was 1.53 (1.44, 1.63) (Fig. 5).

4. Discussion

Based on our study findings, we observed that for every 1 °C rise in the SD of temperature, the risk of mortality among stroke patients increased by 18 %. Additionally, for every 1 °C increase in the DTR, the risk of mortality among stroke patients increased by 69 %. Studies conducted in Zhejiang, China [27], and in sub-Saharan Africa [34] found an association between temperature change and cardiovascular disease mortality. As an example, a Zhejiang study found that short-term TV increases cardiovascular mortality by 1.7 % per 1 °C. Likewise, in sub-Saharan Africa, a comparable association was identified between TV and mortality related to cardiovascular diseases. In a separate study in 16 Chinese cities, elevated short-term TV was correlated with an increase in mortality due to stroke [17]. Comparatively, the impact of the DTR on the risk of death among stroke patients exhibited a stronger association compared to the SD of temperature. The SD of temperature is an important meteorological indicator reflecting the adverse health effects associated with continuous weather stability [35]. As opposed to the SD, the DTR is usually used to measure intraday TV and rarely used to measure long-term TV, yet it is often linked to an increased risk of cause-specific mortality, especially cardiovascular disease [36,37]. Long-term TV-associated mortality among patients with ischemic stroke was positively correlated in our study. Several studies in this area have shown that ambient temperature is associated with the type of stroke [28,38,39]. Most likely because we studied the long-term effects of temperature rather than the short-term effects and we studied the risk of death among stroke patients, our findings showed that the DTR had a significant positive effect on the risk of death among patients with hemorrhagic stroke, in contrast to previous studies [40]. Some previous studies have reported a negative association between daily temperature and hemorrhagic stroke across different temperature ranges and

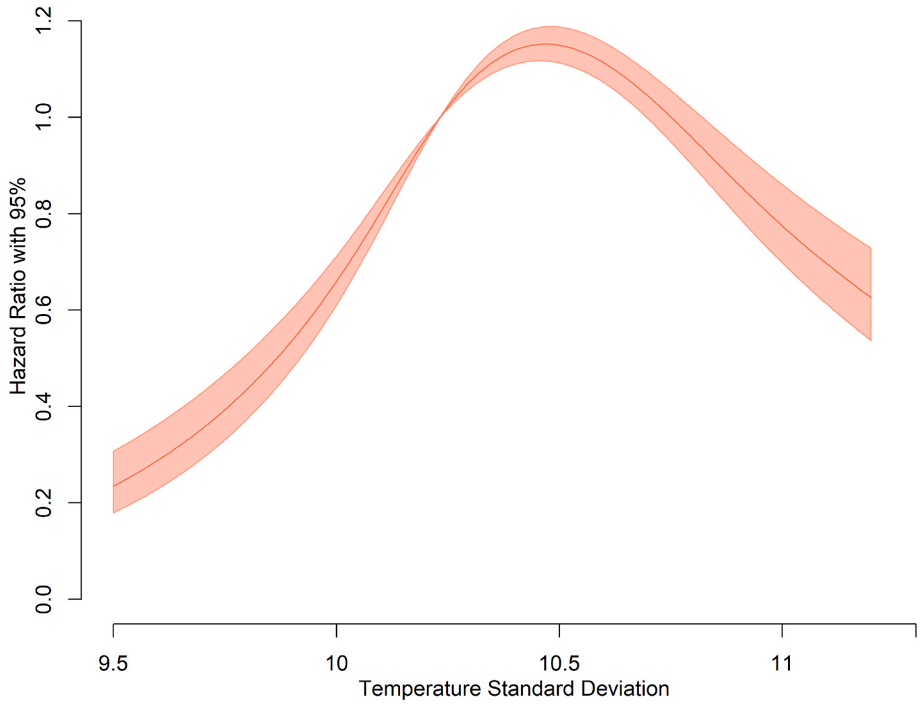

Fig. 2. Exposure-response relations between long-term exposure to temperature standard deviation and the death in stroke patients among Shandong, using a natural spline function with three degrees of freedom. Hazard ratios were estimated by comparing them to a reference value of 10.23 °C (the median of the temperature standard deviation).

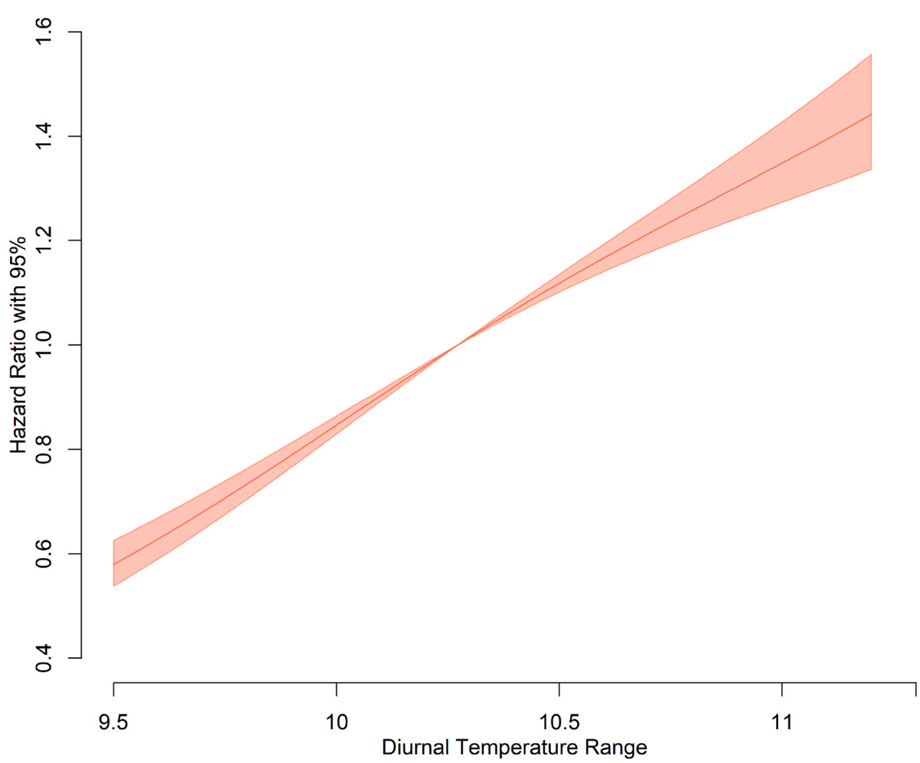

Fig. 3. Exposure-response relations between long-term exposure to diurnal temperature range and the death in stroke patients among Shandong, using a natural spline function with three degrees of freedom. Hazard ratios were estimated by comparing them to a reference value of 10.27 °C (the median of the diurnal temperature range).

seasons. The underlying mechanisms of TV on cardiovascular disease are not yet fully understood. Some studies propose that the detrimental effects of TV on health may be attributed to disruptions in normal physiological thermoregulation. This can occur when the automatic thermoregulatory system struggles to adapt swiftly to rapid environmental temperature fluctuations that exceed the limits of tolerability [20]. Consequently, these disturbances may trigger autonomic activation, resulting in increased cardiovascular workload, such as elevated

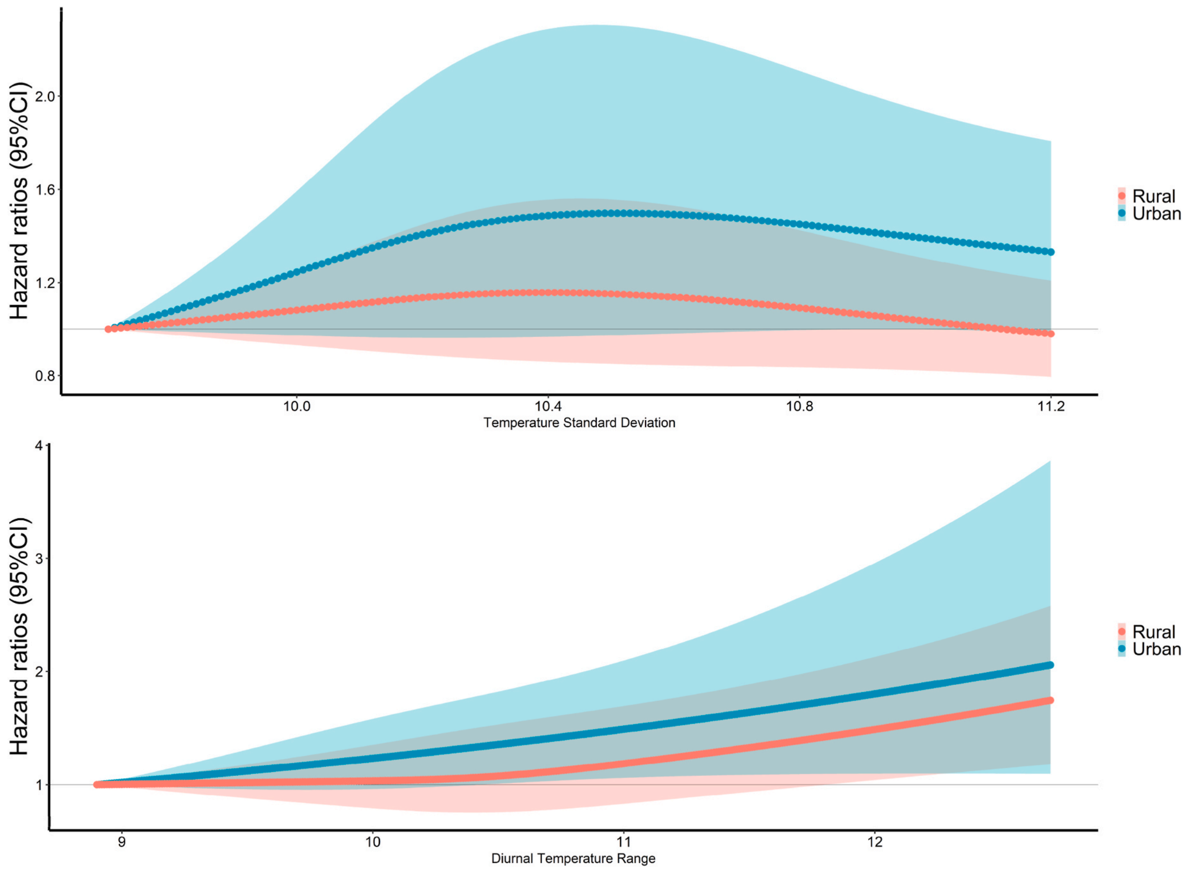

Fig. 4. Exposure-response relationships between long-term exposure to temperature variability (temperature standard deviation and diurnal temperature range) and death in stroke patients (using a natural spline function with three degrees of freedom) were explored in Shandong by dividing stroke patients into urban and rural areas through urbanity, respectively.

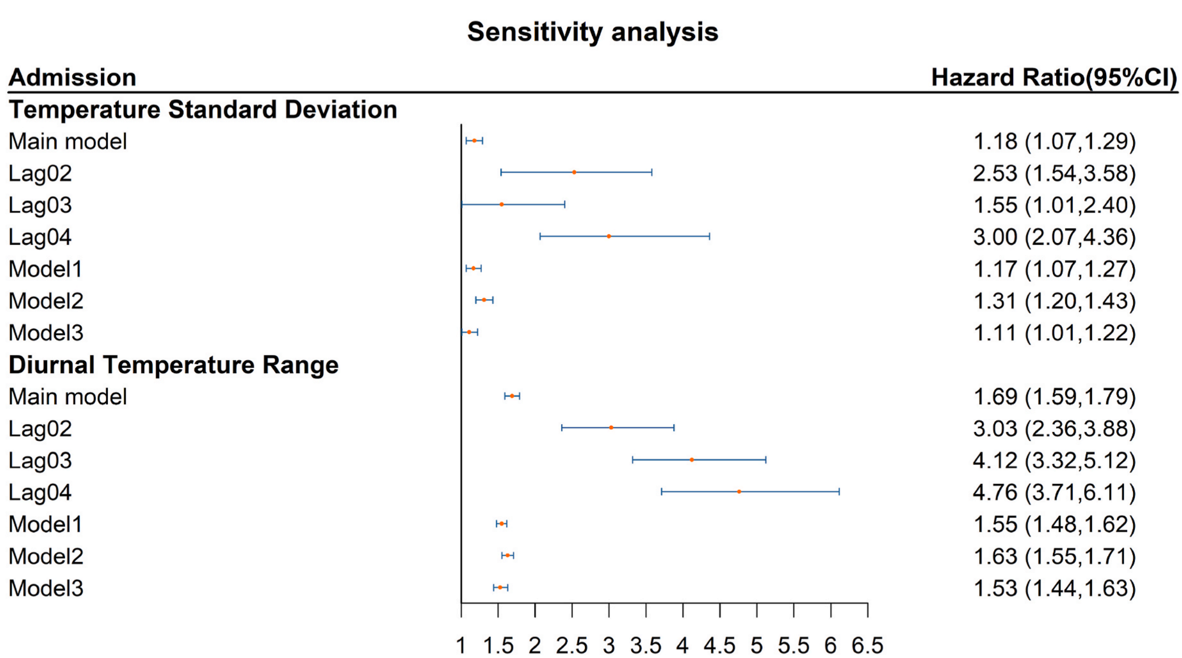

Fig. 5. Hazard Ratio and 95 % confidence intervals with per 1 °C increment in temperature variability on the death in stroke patients in the sensitivity analysis.

heart rate and blood pressure. This further induces the possibility of atherosclerotic cardiovascular disease [12]. A number of studies have demonstrated the link between temperature fluctuations and various physiological changes, including elevated serum cholesterol levels, increased blood pressure, and heart rate, enhanced platelet aggregation, higher blood viscosity, peripheral vasoconstriction, and increased plasma fibrinogen concentration [37,41,42]. These physiological alterations can exert an additional burden on the cardiovascular system, potentially leading to a heightened risk of fatal stroke occurrences [38].

The effects of TV were found to be similar among male and female stroke patients. Evidence suggests that men, who often engage in physical work and outdoor activities, may be more vulnerable to weather changes [43]. Physiological factors make women more sensitive to temperature fluctuations [16,17], however. In our age-stratified analysis, we observed that patients across all age groups were susceptible to the effects of the DTR. The increased vulnerability of younger populations to TV can be attributed to higher occupational exposure [44], while among older adults, their susceptibility to TV may be explained by reduced thermoregulation and the presence of chronic diseases [45]. Furthermore, from our research, we showed a relationship between exposure to the long-term DTR and stroke mortality in urban residents. Urbanization brings forth a multitude of factors that contribute to heightened health risks. These encompass a range of aspects, such as deteriorating air quality due to pollution, income inequality leading to disparities in access to health care, occupational risks associated with specific urban industries, and the increased prevalence of traffic hazards and accidents in urban environments. Collectively, these factors contribute to the increased health risks associated with urbanization [46]. In addition, we found that long-term exposure to TV (including the SD of temperature and the DTR) was positively associated with mortality among stroke patients in a rural population. Because Chinese farmers have lower educational attainment, lower annual income, poor living conditions, and more weather-dependent agricultural practices, farmers who spend more time in the fields may be at greater risk for long-term exposure to environmental TV [47–49]. The identification of subgroups that are particularly susceptible to the adverse health effects associated with TV exposure is of the utmost importance in developing effective prevention strategies. By pinpointing these vulnerable subgroups, we can tailor interventions and allocate resources more efficiently to mitigate the negative impact of TV on health. This knowledge can inform targeted interventions to protect these vulnerable populations and minimize the harmful health impacts of temperature fluctuations.

The paper, with a representative sample of Chinese adults aged 40 and older, examined the effects of TV on stroke patients in one of the few studies to investigate the relationship between long-term TV and health outcomes. Besides, TV acquired at high spatial resolution improves the accuracy of environmental TV assessments. However, the current work also has several potential limitations. First, this study did not consider the issue of individual perception of temperature, which may be affected not only by ambient temperature but also by humidity and wind chill. Second, we didn't collect some of the other factors that influence death in stroke patients, such as personal factors like whether or not they have high blood pressure and other behavioral factors. Third, we did not collect information on air conditioning or room temperature, such as the effects of room air conditioning use and room temperature, so we could not fully adjust for potential confounding factors, and future studies should focus more on these solutions.

5. Conclusion

In summary, the findings of this study provide valuable insights into the relationship between prolonged TV exposure and health. By prioritizing research in this area, we can gain a deeper understanding of the specific mechanisms and pathways through which TV impacts health, enabling the development of targeted interventions and policies. The key findings can be summarized below.

- Our study shows that long-term temperature variability (temperature SD and DTR) is positively associated with death in stroke patients and that the risk of death in stroke patients increases as long-term temperature variability increases.
- We also analyzed deaths among patients with different types of stroke. The SD of temperature and the DTR were positively associated with death among ischemic stroke patients, whereas only the DTR was positively associated with death among hemorrhagic stroke patients.
- The effect of long-term temperature variability on death in stroke patients was statistically significant in different age groups.
- Long-term temperature variability has a lagged effect on the risk of death in stroke patients.
- It is recommended that public health organizations allocate more resources and attention to a comprehensive understanding of the health risks associated with long-term temperature variability.

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CRediT authorship contribution statement

Peiyao Zhang: Writing – original draft, Visualization, Formal analysis, Data curation. **Zhe Kan:** Resources, Investigation. **Ke Zhao:** Validation, Software. **Chengrong Liu:** Software, Investigation. **Chao Liu:** Resources, Investigation. **Wanning Xia:** Resources, Investigation. **Chunxiang Shi:** Resources, Investigation. **Jing Wei:** Resources, Investigation. **Bingyin Zhang:** Resources, Project administration. **ZiLong Lu:** Supervision, Project administration. **Fuzhong Xue:** Supervision, Investigation. **Xiaolei Guo:** Supervision, Project administration. **Xianjie Jia:** W. **Jing Mi:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.buildenv.2024.111159.

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