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Ambient Temperature and Injury-Related Hospital Admissions in China: A 10-Year Time-Series Analysis Using Distributed Lag Non-linear Model

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Abstract

Background Ambient temperature is an important environmental factor affecting population health. While its effects on mortality and chronic diseases have been widely studied, less is known about its role in injury risk. In rapidly urbanizing settings, temperature may influence injury occurrence through changes in behavior, mobility, and exposure patterns. This study aimed to examine the association between ambient temperature and injury-related hospital admissions in Shanghai, China.

Methods A time-series analysis was conducted using daily injury-related hospital admissions in Shanghai from 2016 to 2025. Meteorological data, including daily mean temperature and relative humidity, were obtained from local monitoring systems. The association between temperature and injury-related hospital admissions was assessed using a distributed lag non-linear model to account for non-linear and delayed effects. Subgroup analyses were performed by age, sex, and injury mechanism.

Results A total of 2,000,847 injury-related hospital admissions were included. The relationship between ambient temperature and injury-related hospital admissions showed a non-linear pattern, with the highest risk observed at moderate temperatures. At higher temperatures, the overall risk decreased, although traffic-related injuries continued to increase. In contrast, fall-related injuries showed a declining trend at high temperatures. Heat-related effects were short-term, while cold-related effects were weaker and more gradual. Subgroup analyses indicated higher risks among younger adults under high temperatures and slightly increased risks among older adults under cold conditions.

Conclusions Ambient temperature is associated with injury risk in a non-linear and mechanism-specific manner. The overall pattern reflects the combined effects of different injury types with distinct responses to temperature. These findings suggest that injury prevention strategies should consider not only extreme temperatures but also moderate conditions, as well as population differences and behavioral factors. Integrating temperature-related risks into urban planning and public health strategies may help reduce the injury burden in the context of climate change.

Background

Injury is a major global public health burden and one of the leading causes of death and disability worldwide, particularly in relation to traffic accidents, falls, occupational injuries, and interpersonal violence [1]. According to the World Health Organization, injuries account for approximately 4.4 million deaths annually, representing about 8% of global mortality [2]. In China, rapid urbanization, high population density, and changing behavioral patterns have further amplified injury risk, making injury the fifth leading cause of death and imposing substantial economic and healthcare burdens [3–4]. While high-income countries have achieved significant reductions in injury burden through policy interventions, infrastructure improvements, and optimized injury care systems, the applicability of these strategies in China remains uncertain due to differences in environmental conditions, governance structures, and healthcare system capacity [5].

In parallel, environmental exposures, particularly ambient temperature, have emerged as critical determinants of population health. Rather than exerting a simple linear effect, temperature-health relationships are typically non-linear, with both high and low temperatures contributing to increased risks of mortality and morbidity. Large multi-country studies have demonstrated that temperature-related health impacts follow a U- or J-shaped pattern, with risks increasing at both ends of the temperature spectrum [6–8].

Importantly, risk magnitude and population burden are not equivalent. While extreme temperatures may confer higher relative risks, moderately high or moderately low temperatures occur far more frequently and therefore contribute a larger share of the overall health burden [9–11]. A substantial proportion of excess mortality has been attributed to moderately high or moderately low temperatures, which occur more frequently and affect larger populations. This challenges the conventional focus on extreme heatwaves and cold spells as the primary drivers of temperature-related health risk.

Against the background of ongoing climate change, global surface temperatures have increased by approximately 1.2°C above pre-industrial levels, with the past decade being the warmest on record [12]. This shift is expected to alter the distribution of temperature exposure and associated health risks, particularly in densely populated urban environments. Vulnerable populations, including older adults, are disproportionately affected by both heat and cold exposures [13–14].

Despite this growing body of evidence, research on temperature-related health effects has largely focused on mortality and cardiorespiratory outcomes. Comparatively less attention has been paid to injury, a major and preventable contributor to the global disease burden. Moreover, the relationship between environmental exposure and injury is complex and multifaceted. Existing studies have often focused on overall injury counts, with limited exploration of differences across injury mechanisms. In addition, few studies have systematically examined the nonlinear and lagged effects of environmental exposures on injury outcomes.

Shanghai provides a particularly relevant setting to address these gaps. As one of China’s most populous and economically dynamic cities, its large population, high urban density, and distinct climatic conditions offer a valuable context for investigating injury patterns and environmental health relationships in rapidly urbanizing settings.

Therefore, this study aimed to examine the association between ambient temperature and injury-related healthcare utilization in Shanghai using a Distributed Lag non-linear Model (DLNM). Specifically, we sought to characterize the exposure-response relationship, assess lagged and cumulative effects, and explore heterogeneity across population subgroups and injury mechanisms.

Methods

Study population

Injury-related hospital admissions data were obtained from the Shanghai Health Information Statistics Center, which maintains a citywide administrative database covering all secondary and tertiary hospitals in Shanghai. The database includes detailed information on patient demographics, diagnoses, and clinical outcomes. For this study, all injury-related hospital admissions recorded between 2016 and 2025 were extracted. Injury cases were identified using ICD-10 injury diagnosis codes (S00-T98) and external cause codes (V01-Y98). To improve case ascertainment, injury cases were systematically identified by integrating information from the primary diagnosis, external cause codes, and chief complaints recorded in the medical records.

Health outcomes

Based on the study objectives, two categories of information were extracted from the database. Data related to the burden of injury were used for city-level time-series analyses, including the daily number of injury-related hospital admissions, admission dates, and basic demographic characteristics of patients. Additional variables related to clinical characteristics and outcomes, including admission route, discharge status, and inpatient diagnosis, were extracted for descriptive analyses.

Environmental data

The meteorological data used in this study were obtained from the Shanghai Meteorological Service (http://sh.cma.gov.cn/), including daily mean temperature (°C), atmospheric pressure (hPa), wind speed (m/s), and relative humidity (%). Air pollutant data were obtained from the official website of the Shanghai Ecological Environment Bureau (https://sthj.sh.gov.cn/), including particulate matter with an aerodynamic diameter of less than 2.5 μm (PM2.5, μg/m³) and 10 μm (PM10, μg/m³), carbon monoxide (CO, mg/m³), nitrogen dioxide (NO2, μg/m³), sulfur dioxide (SO2, μg/m³), and ozone (O3, μg/m³).

Ambient temperature was defined as the daily mean temperature and was treated as a continuous exposure variable in the analysis. To account for potential distributed lag non-linear effects, temperature was modeled using a distributed lag nonlinear framework. Extreme temperature exposures were defined based on the temperature distribution, with extreme cold and extreme heat corresponding to the 2.5th and 97.5th percentiles of daily mean temperature, respectively. These percentile-based thresholds were used to estimate lag-specific and cumulative effects of temperature on injury risk. The datasets supporting the conclusions of this article are included within the Additional file 1.

Statistical analysis

To characterize the delayed and potentially non-linear effects of temperature on injury-related hospital admissions, a DLNM was applied. DLNM has been widely used in environmental epidemiology to assess the health impacts of meteorological exposures and other environmental factors. Given that daily injury-related hospital admissions represent count data, a quasi-Poisson regression combined with a DLNM

framework was used to estimate the association between temperature exposure and daily hospital admissions.

The lag dimension was incorporated to capture the temporal structure of temperature effects. A maximum lag of 14 days was specified to evaluate both delayed and cumulative effects of temperature. The lag structure was examined through single-day lag effects (lag 0–14) and cumulative lag effects (lag 0–1 to lag 0–14).

The model can be expressed as:

$$log(E(Y_t)=a + cb(Temp_t,lag) + ns(Mete_t,df=4) +ns(Pollut_t,df=4)+ ns(Time_t,df=4) + Dow + Holiday$$

where $\mathrm{Y_t}$ represents the number of injury-related hospital admissions on day t; $\mathrm{cb(Temp_t,lag)}$ denotes the cross-basis matrix of temperature constructed within the DLNM framework to simultaneously model the non-linear exposure-response relationship and the lagged effects of temperature; $\mathrm{ns()}$ represents a natural cubic spline function; Mete are meteorological factors, including relative humidity and wind velocity, controlled by a natural cubic spline with four degrees of freedom; Pollut are pollution factors, including CO, NO2, SO2, O3, PM10, PM2.5, also controlled by a natural cubic spline with four degrees of freedom; $\mathrm{Time_t}$ represents calendar time used to control for long-term trends and seasonality; Dow indicates the day of the week; and $\mathrm{Holiday}$ represents public holidays.;

The minimum morbidity temperature (MMT) was defined as the temperature corresponding to the lowest predicted risk of injury-related hospital admissions. This value was used as the reference temperature to estimate relative risks (RR) and their corresponding 95% confidence intervals (95% CI).

To explore potential effect modification, subgroup analyses were conducted according to sex (male and female), age group (18–44, 45–59, and ≥ 60 years), and injury mechanisms. Separate DLNM models were fitted for each subgroup using the same model specification.

Sensitivity analyses were performed to assess the robustness of the results. Specifically, the maximum lag period was varied (14, 21, and 28 days), and the degrees of freedom for spline functions of meteorological variables and long-term trends were modified. The consistency of the exposure-response relationships across these model specifications was evaluated.

All analyses were conducted using R software (version 4.3.3). Distributed lag non-linear models were implemented using the DLNM package, and additional statistical analyses were performed using standard R packages.

Results

Exposure and population characteristics

A total of 2,000,847 injury-related hospital admissions were recorded in Shanghai from 2016 to 2025. Among them, 1,080,237 (53.99%) were male and 920,610 (46.01%) were female. The mean age of the study population was 53.98 ± 20.83 years, with 69.2% of cases occurring among individuals aged 45–59 years and ≥ 60 years.

The leading mechanisms of injury were falls (55.09%) and traffic accidents (14.45%), with mean daily hospital admissions of 302.07 ± 97.24 and 72.80 ± 26.20 cases, respectively. Regarding discharge outcomes, most patients were discharged as cured (47.72%) or improved (47.32%), accounting for over 95% of all cases. In contrast, a relatively small proportion of patients were not recovered (1.97%) or had unknown outcomes (2.34%), and deaths accounted for only 0.65% (Table 1). Figure 1. also presents the time-series distribution of daily injury-related hospital admissions alongside ambient temperature from 2016 to 2025.

Table 1
Patient baseline characteristics

Variables		Counts(n)	Percent(%)	Mean ± SD
Sex				
	Male	1080237	53.99	/
	Female	920610	46.01	/
Age				53.98 ± 20.83
	18–44	505754	25.3	/
	45–59	518952	25.9	/
	≥ 60	866494	43.3	/
	Unknown	109647	5.5	/
Discharge outcome	Cures	954832	47.72	286.81 ± 91.90
	Death	13087	0.65	3.93 ± 2.30
	improved	946766	47.32	284.49 ± 109.90
	Not recovered	39388	1.97	11.84 ± 4.89
	Unknown	46774	2.34	13.05 ± 3.62
Mechanism of Injuries				
	Fall	1102251	55.09	302.07 ± 97.24
	Traffic Accident	265643	13.28	72.80 ± 26.20
	Assault	238124	11.90	65.26 ± 22.67
	Unintentional Injure	232534	11.62	63.72 ± 30.72
	Other	162295	8.11	45.63 ± 8.76

During the study period, the mean daily temperature was 18.33 ± 8.67°C, and the mean relative humidity was 71.77 ± 13.97%. The average concentrations of air pollutants were 3.80 ± 6.51 mg/m³ for CO, 36.44 ± 17.62 μg/m³ for NO_2, 7.89 ± 3.67μg/m³ for SO_2, 89.16 ± 41.39 μg/m³ for O_3, 46.04 ± 26.65 μg/m³ for PM_{10}, and 33.87 ± 23.27 μg/m³ for $PM_{2.5}$ (Table 2).

Table 2
Descriptive statistics of environmental factors in Shanghai, 2016–2025.

Variables		Mean ± SD	Min	25th	50th	75th	Max
Meteorological factors							
	Ambient temperature (°C)	18.33 ± 8.67	−5.2	10.8	18.9	25.7	35.6
	Relative humidity (%)	71.77 ± 13.97	24.0	63.0	72.1	82.0	100.0
	Wind velocity(m/s)	0.97 ± 1.17	0	0.3	0.5	0.9	10.2
Air pollution levels							
	CO (mg/m^3)	3.80 ± 6.51	0.3	0.6	0.7	1.0	35.0
	NO_2 ($\mu g/m^3$)	36.44 ± 17.62	4	23	33	46	117
	SO_2 ($\mu g/m^3$)	7.89 ± 3.67	3	6	7	9	48
	O_3 ($\mu g/m^3$)	89.16 ± 41.39	8	59	84	112	269
	PM_{10} ($\mu g/m^3$)	46.04 ± 26.65	6	28	39	57	325
	$PM_{2.5}$ ($\mu g/m^3$)	33.87 ± 23.27	3	18	28	43	214

The association between ambient temperature and injury-related hospital admissions

The overall exposure-response relationship between daily mean temperature and injury-related hospital admissions is shown in Fig. 2. The association exhibited a non-linear pattern, characterized by an inverted U-shaped curve. Compared with the reference temperature, the relative risk of injury-related hospital admissions increased gradually with rising temperature and reached a peak at approximately 16.4 ℃(RR = 1.104, 95% CI = 1.04, 1.15). As temperature continued to increase beyond this level, the relative risk gradually declined.

At lower temperatures, the estimated relative risks were below the reference level, indicating a lower risk of injury-related hospitalizations. The highest risk was observed at moderate temperatures, whereas extremely high temperatures did not correspond to further increases in hospitalization risk. Uncertainty increased at the temperature extremes, as reflected by wider confidence intervals.

Furthermore, traffic injuries showed a progressively increasing risk with rising temperature, particularly in the higher temperature range. Assault-related admissions showed a more pronounced non-linear pattern, with the risk increasing rapidly at lower-to-moderate temperatures, peaking at 12.2℃ (RR = 1.22, 95% CI = 1.11, 1.34).

The effect of extreme events with different characteristics

Figure 3. shows the cumulative and lag-specific effects of extreme cold (2.9℃, 2.5th percentile) and heat(32 ℃, 97.5th percentile). A modest elevation in RR was observed at lag 0(RR = 1.04, 95% CI = 0.98, 1.11), followed by a brief decline at lag 1–2 and a slight rebound during lag 3–5. Overall, the heat-related lag-specific effects appeared short-lived, with confidence intervals overlapping 1 for most lag days.

Under extreme cold exposure, the cumulative relative risk remained close to the null in the early lag period and then showed a slight upward trend over time. The estimated cumulative RR gradually increased at longer lags, reaching approximately(RR = 1.03, 95% CI = 1.02, 1.04) by the end of the lag period. However, the magnitude of the association was small, and the confidence intervals remained close to unity across most lag days.

The red curve represents the cumulative effect of extreme cold (2.9℃, 2.5th percentile), and the blue curve represents the lag-specific effect of extreme heat (32℃, 97.5th percentile). RR: relative risk; CI: confidence interval. The dashed horizontal line denotes the null value (RR = 1)

Subgroup analyses

Figure 4. shows the subgroup analysis of high-temperature exposure, heterogeneity in the temperature-injury association was observed across sex, age groups, and injury mechanisms. Under high-temperature exposure, age-stratified analyses showed a significant increase in injury-related hospital admissions among individuals aged 18–44 years (RR = 1.26, 95% CI: 1.10–1.45). In contrast, a significant inverse association was observed among those aged ≥ 60 years (RR = 0.85, 95% CI: 0.76–0.96). When stratified by injury mechanism, high temperature was significantly associated with an increased risk of traffic-related injuries (RR = 1.29, 95% CI: 1.11–1.51). Conversely, a significant negative association was found for falls (RR = 0.82, 95% CI: 0.70–0.96).

Under low-temperature exposure, the associations between temperature and injury admissions were generally modest and showed limited heterogeneity across subgroups.

Age-stratified analyses indicated a small but statistically significant decrease among individuals aged 18–44 years (RR = 0.97, 95% CI: 0.96–0.99). No significant association was observed in the 45–59 age group (RR = 0.99, 95% CI: 0.98-1.00). In contrast, a marginal increase in risk was observed among those aged ≥ 60 years (RR = 1.07, 95% CI: 1.00-1.12).

Sensitivity analyses

Sensitivity analyses using alternative maximum lag periods (14, 21, and 28 days) demonstrated consistent exposure-response relationships between ambient temperature and injury risk. All models showed a similar non-linear pattern, with increased risk at moderate temperatures and attenuation at higher temperatures.

While extending the lag period resulted in modest changes in the magnitude of the estimated effects, the overall shape and key features of the association remained stable. The peak risk at moderate temperatures was consistently observed across all lag specifications, indicating that the main findings are not sensitive to the choice of lag structure (Fig. 5.).

Discussion

In this time-series study conducted in Shanghai, we identified a non-linear association between ambient temperature and injury-related hospital admissions, characterized by an inverted U-shaped exposure-response relationship. The highest risk occurred at moderate temperatures, whereas both low and high temperatures were associated with comparatively lower risks. In addition, the temporal patterns differed between heat and cold exposures, and substantial heterogeneity was observed across age groups and injury mechanisms.

Our findings are broadly consistent with previous studies demonstrating that ambient temperature influences injury occurrence, particularly for traffic injuries and falls. Prior time-series analyses and case-crossover studies have reported increased injury risks under both high and low temperatures, often with variation by injury mechanisms [15–16]. However, in contrast to the predominantly monotonic or V-shaped relationships reported in earlier studies, we observed an inverted U-shaped association, with peak risk at moderate temperatures. This pattern has also been reported in recent work and aligns with evidence suggesting that the majority of temperature-related health burden may arise from moderate rather than extreme temperatures [17–18]. The observed inverted U-shaped relationship is best interpreted through the interaction between behavioral exposure and physiological responses. At moderate temperatures, levels of outdoor activity, commuting, and social interaction are typically highest, increasing exposure to traffic environments, occupational hazards, and interpersonal risks[19]. By contrast, at temperature extremes, behavioral avoidance appears to dominate. Individuals tend to reduce outdoor activities during both hot and cold conditions, thereby limiting exposure to injury-prone environments.

Differences in outcome definitions may also contribute to the observed discrepancy. While many studies rely on emergency department visits or ambulance dispatches, which capture more immediate and less severe events, our study focused on hospital admissions, which likely reflect more severe injuries and are influenced by healthcare-seeking behavior and admission thresholds.

The inverted U-shaped association for overall injury-related hospital admissions likely reflects the combined contribution of different injury mechanisms with distinct temperature-response patterns, rather than a uniform response across all injury types. While overall admissions peaked at moderate

temperatures, traffic-related injuries increased progressively with rising temperature, indicating that the aggregate curve should not be interpreted as a single underlying mechanism. A plausible explanation is that warmer conditions increase mobility, road use, and travel-related exposure, while also impairing concentration, reaction time, and emotional regulation, thereby elevating crash risk [20–22]. In contrast, other mechanisms, particularly falls, may decline under very hot conditions because vulnerable populations reduce outdoor activity and mobility. The overall inverted U-shaped relationship may therefore represent the net effect of heterogeneous mechanism-specific responses to temperature.

This mechanism-specific interpretation is further supported by the subgroup analyses. The positive association between high temperature and traffic-related injuries likely reflects increased exposure to traffic environments combined with heat-related impairments in cognitive and behavioral performance [13, 23]. By contrast, the inverse association between high temperature and fall-related hospital admissions is more plausibly explained by reduced exposure among vulnerable populations rather than any protective physiological effect of heat. Under very hot conditions, particularly among middle-aged and older adults, reductions in outdoor mobility and travel may substantially decrease opportunities for fall-related injury [13, 19]. Together, these findings highlight that temperature does not influence all injuries uniformly; instead, its impact depends strongly on exposure patterns, behavioral responses, and the specific pathways through which injuries occur.

The lag effect analyses further highlight distinct temporal patterns between heat and cold exposure. Heat-related effects were acute and short-lived, with the strongest associations observed within the first few days following exposure. This is consistent with mechanisms involving rapid changes in fatigue, attention, dehydration, and behavioral responses, which may increase injury risk within a narrow time window [20, 24–25]. By contrast, the cumulative effect of cold exposure was weaker in magnitude but more gradual, showing a modest increase over longer lag periods. This pattern suggests that cold-related injury risk may operate through slower and more indirect pathways, including impaired balance, reduced dexterity, delayed mobility-related consequences, and prolonged exposure to hazardous environments. Similar prolonged lag structures have been reported in studies of temperature-related mortality, supporting the notion that cold effects tend to be delayed and sustained [26–27].

The relatively modest magnitude of cumulative cold effects observed in Shanghai should also be interpreted in the context of local climatic and urban conditions. Winters in Shanghai are comparatively mild, and prolonged icy conditions are uncommon. In a highly urbanized setting with well-developed infrastructure, indoor-oriented lifestyles, and accessible healthcare services, the injury burden attributable to cold exposure may be attenuated. These contextual factors may explain why cold-related effects were present but limited, and why the overall exposure-response relationship was dominated by moderate temperatures [19, 28–29].

The subgroup analyses further demonstrate that temperature-related injury risk is strongly shaped by differences in exposure patterns and behavioral responses. Younger adults exhibited the most pronounced increase in injury-related hospital admissions under high-temperature conditions, likely

reflecting higher levels of mobility, occupational exposure, and participation in outdoor and traffic-related activities [18, 30]. In contrast, older adults showed reduced risk under high temperatures and only marginal increases under cold exposure, which may be explained by greater behavioral adaptation, including reduced outdoor activity during adverse weather conditions. Nevertheless, the slightly elevated risk among older adults under cold conditions remains biologically plausible, given age-related declines in balance, muscle strength, and thermoregulation [31].

These findings have important implications for injury prevention in urban environments under climate change. First, the burden of temperature-related injury is not confined to extreme events. Moderate temperatures, which are associated with higher levels of daily mobility and exposure, may contribute substantially to injury risk. This suggests that prevention strategies focusing exclusively on heatwaves or cold spells may overlook a significant proportion of temperature-related injuries. Second, the observed association between high temperature and traffic-related injuries is consistent with previous evidence linking warmer conditions to increased crash risk. From a public health perspective, this underscores the need to integrate climate-sensitive risk factors into transport systems and urban planning. Recent frameworks have emphasized the importance of incorporating environmental exposures into health adaptation strategies in urban settings [13].Incorporating temperature information into traffic safety management, risk communication, and occupational protection strategies may enhance urban resilience. Third, age-specific differences further highlight the need for targeted interventions. Younger populations, who are more frequently exposed to traffic environments, may benefit from strengthened transport safety measures, while older adults may require fall-prevention strategies, particularly under adverse environmental conditions. Such stratified approaches are consistent with existing public health frameworks for injury prevention [32–33].

More broadly, our findings support the integration of injury outcomes into climate-health adaptation frameworks. As climate change alters thermal exposure patterns and human mobility in urban environments, injury epidemiology may also shift. Incorporating injury surveillance into climate early warning systems and urban planning strategies will be essential for reducing future health burdens.

This study has several strengths. It was based on a large, multi-institution dataset spanning ten years and more than two million injury-related hospital admissions, providing substantial statistical power. The application of DLNM allowed us to capture both non-linear and lagged associations. In addition, the stratified analyses by age, sex, and injury mechanism provided important insights into heterogeneity that are not captured in aggregate analyses.

Several limitations should also be acknowledged. First, as an ecological time-series study, causal inference at the individual level is limited. Second, exposure assessment relied on area-level meteorological data, which may not reflect individual-level exposure and may introduce non-differential misclassification. Third, the outcome was restricted to hospitalized injuries and therefore represents only the more severe end of the injury spectrum. Finally, as a single-city study, the generalizability of the findings to other settings may be limited.

In conclusion, temperature-related injury risk in Shanghai is characterized by a non-linear, exposure-dependent pattern shaped primarily by behavioral mechanisms rather than direct physiological effects alone. These findings highlight the importance of considering exposure context, mobility patterns, and population heterogeneity when developing climate-adaptive injury prevention strategies.

Abbreviations

DLNM
Distributed Lag non-linear Model

Declarations

Competing interests

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.

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Author Contribution

Xu Liu and Ziwei Xu conceptualized the study. Xu Liu and Yuan Liu provided access to the data. Ziwei Xu and Jiayue Zhu collected and cleaned the data. Ziwei Xu and Jiayue Zhu analyzed the data with supervision from Yuan Liu and Xu Liu. Ziwei Xu and Jiayue Zhu drafted the first version of the manuscript. All authors read and approved the final manuscript.

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Data availability statement

The datasets generated and/or analyzed during the current study are available from the Shanghai Municipal Health Commission Statistics Center but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however

available from the authors upon reasonable request and with permission of the Shanghai Municipal Health Commission Statistics Center.

Ethics statement

This study was approved by the Committee on Ethics of Medicine, Naval Medical University, PLA (Approval Date: January 20, 2024). Informed consent was obtained from all individual participants included in the study. The study was performed in accordance with the Declaration of Helsinki. Clinical trial number: not applicable.

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Figures

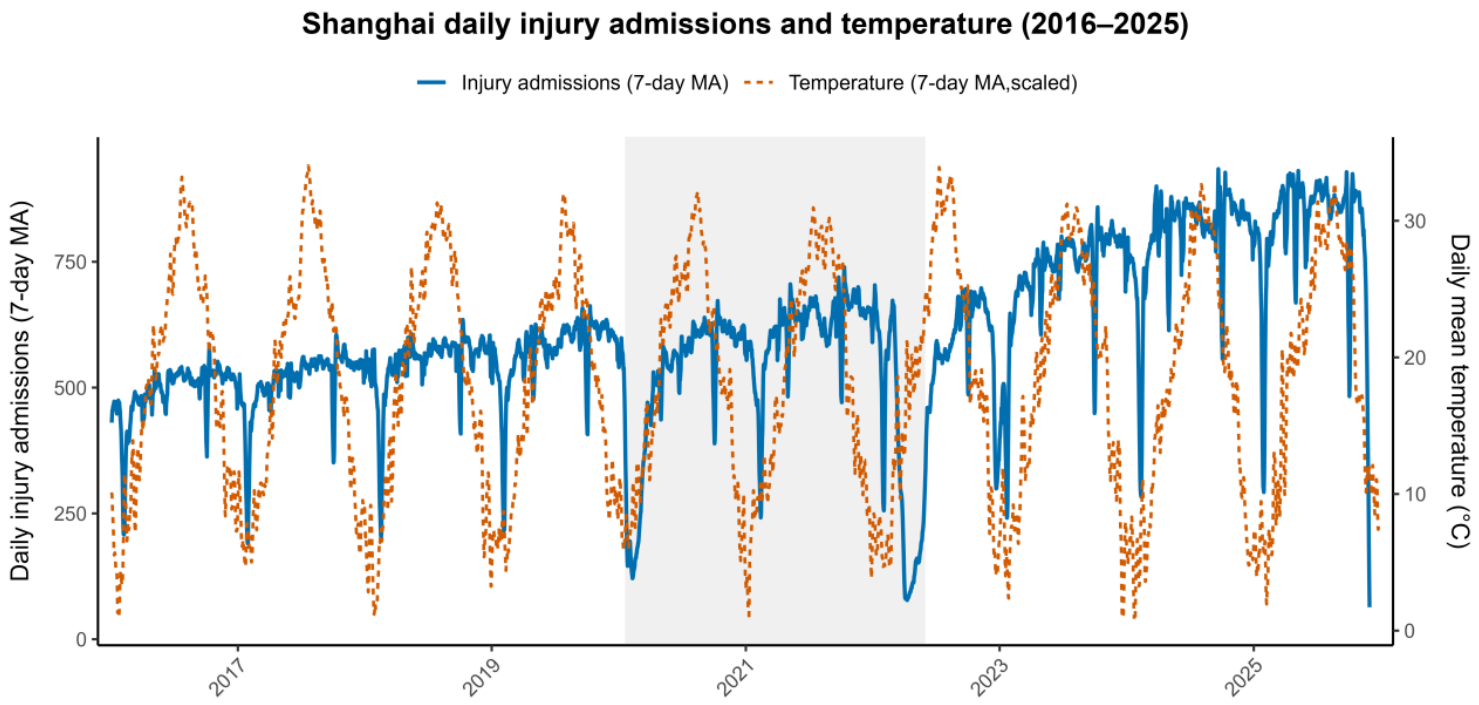


Figure 1

Time series distribution of total injury-related admissions and ambient temperature in Shanghai, 2016-2025

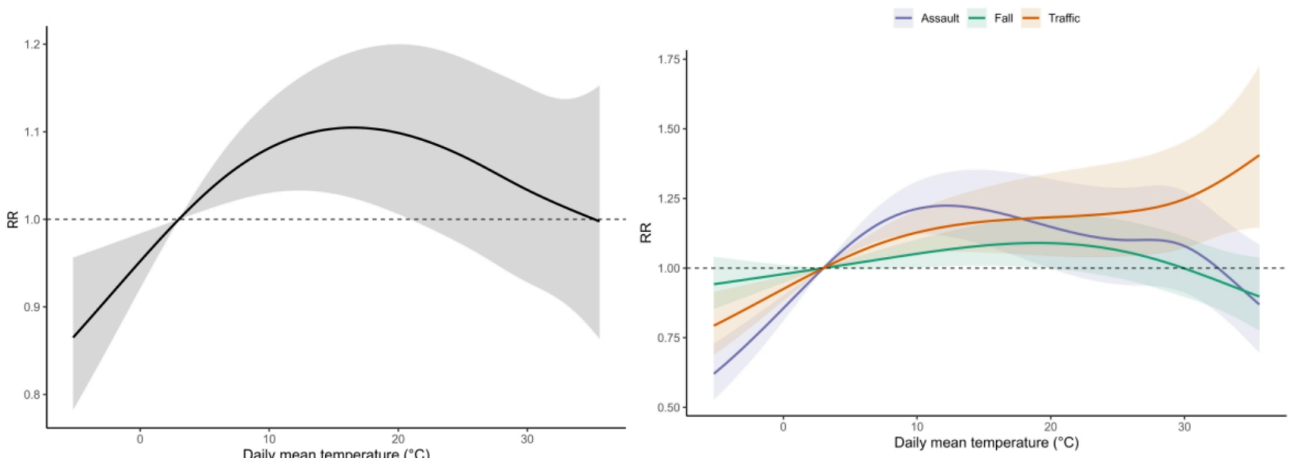


Figure 2

The exposure-response relationship between the ambient temperature (MMT=3℃) and the injury-related hospital admissions in Shanghai, 2016 to 2025. Shaded area is the 95% CI. RR: relative risk; CI: confidence interval

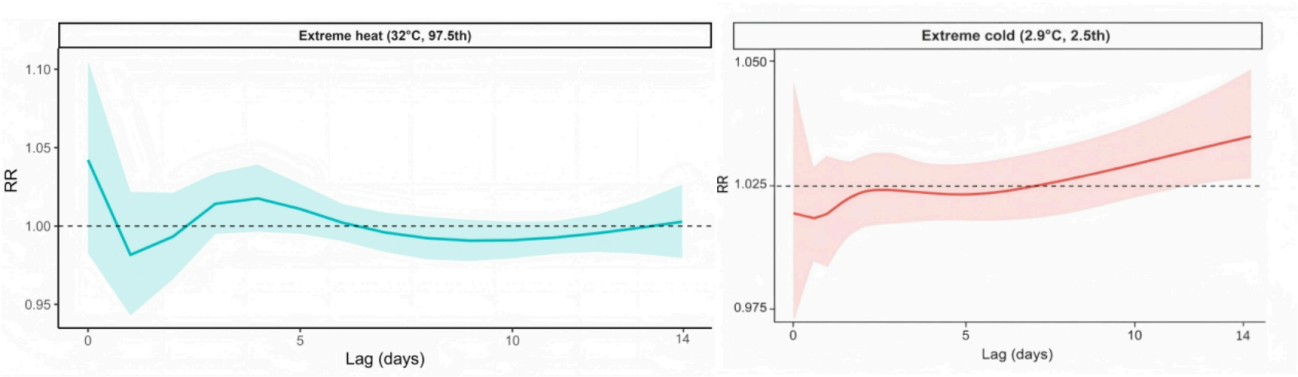


Figure 3

Lag-response associations between extreme temperature exposure and injury risk.

The red curve represents the cumulative effect of extreme cold (2.9℃, 2.5th percentile), and the blue curve represents the lag-specific effect of extreme heat (32℃, 97.5th percentile). RR: relative risk; CI: confidence interval. The dashed horizontal line denotes the null value (RR = 1)

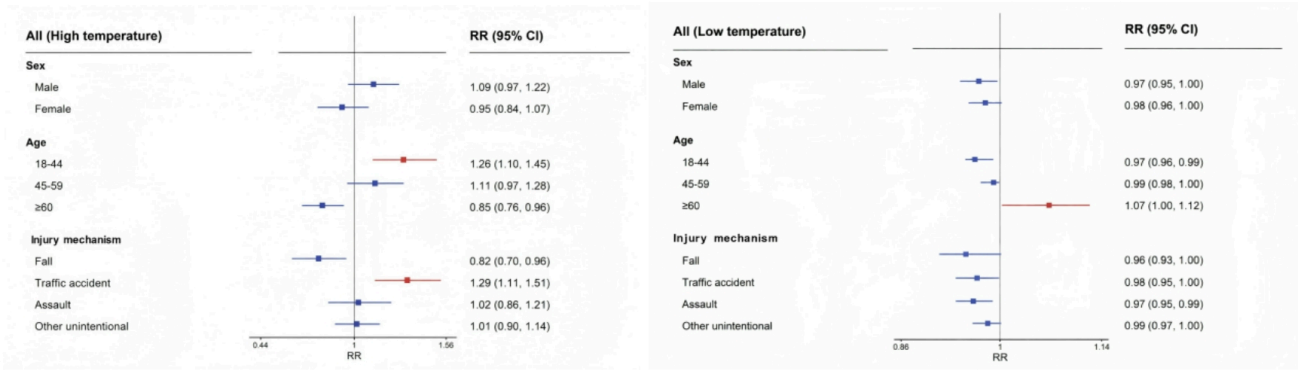


Figure 4

Subgroup analyses of the lagged associations between extreme temperatures (2.9℃, 2.5th percentile; 32℃, 97.5th percentile) and injury-related hospital admissions in Shanghai, 2016-2025. RR: relative risk; CI: confidence interval

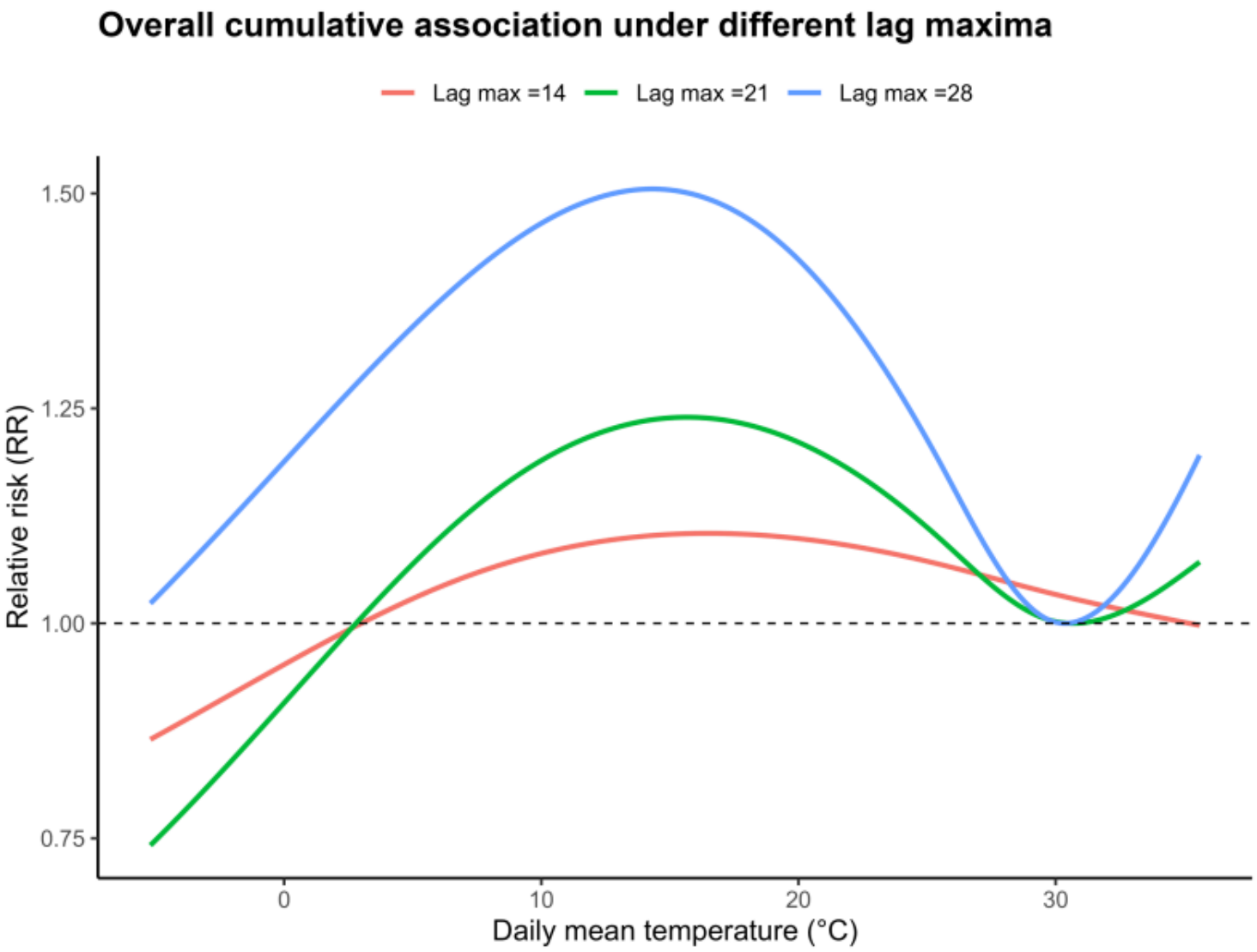


Figure 5

Sensitivity analysis of the ambient temperature and the injury-related hospital admissions under different maximum lag specifications. Curves represent cumulative relative risks (RR) estimated using maximum lag periods of 14, 21, and 28 days. The x-axis denotes daily mean temperature (℃), and the y-axis shows RR. The dashed horizontal line indicates the null value (RR = 1)

Supplementary Files

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- Additionalfile1.xlsx