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# The correlation between daily temperature, diurnal temperature range, and asthma hospital admissions in Lanzhou city, 2013–2020

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## Abstract

**Background** With the backdrop of global climate change, the impact of climate change on respiratory diseases like asthma is receiving increasing attention. However, the effects of temperature and diurnal temperature range (DTR) on asthma are complex, and understanding these effects across different seasons, age groups, and sex is of utmost importance.

**Methods** This study utilized asthma hospitalization data from Lanzhou, China, and implemented a distributed lag nonlinear model (DLNM) to investigate the relationship between temperature and DTR and asthma hospitalizations. It considered differences in the effects across various seasons and population subgroups.

**Results** The study revealed that low temperatures immediately increase the risk of asthma hospitalization (RR = 1.2010, 95% CI: 1.1464, 1.2580), and this risk persists for a period of time. Meanwhile, both high and low DTR were associated with an increased risk of asthma hospitalization. Lower temperatures (RR = 2.9798, 95% CI: 1.1154, 7.9606) were associated with higher asthma risk in the warm season, while in the cold season, the risk significantly rose for the general population (RR = 3.6867, 95% CI: 1.7494, 7.7696), females (RR = 7.2417, 95% CI: 2.7171, 19.3003), and older individuals (RR = 18.5425, 95% CI: 5.1436, 66.8458). In the warm season, low DTR conditions exhibited a significant association with asthma hospitalization risk in males (RR = 7.2547, 95% CI: 1.2612, 41.7295) and adults aged 15–64 (RR = 9.9494, 95% CI: 2.2723, 43.5643). Children also exhibited noticeable risk within specific DTR ranges. In the cold season, lower DTR increases the risk of asthma hospitalization for the general population (RR = 3.1257, 95% CI: 1.4004, 6.9767). High DTR significantly increases the risk of asthma hospitalization in adults (RR = 5.2563, 95% CI: 2.4131, 11.4498).

**Conclusion** This study provides crucial insights into the complex relationship between temperature, DTR, and asthma hospitalization, highlighting the variations in asthma risk across different seasons and population subgroups.

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**Keywords** Asthma, Diurnal temperature range, DLNM, Temperature

## Introduction

In the context of global climate change, the frequency of extreme weather events is on the rise, exerting severe and long-lasting impacts on human health [1]. The IPCC predicts that by the year 2100, the global average surface temperature is expected to increase by 1.8–4.0 °C compared to the period from 1980 to 1999 [2]. Asthma, as a heterogeneous disease, is typically characterized by chronic airway inflammation, including symptoms such as shortness of breath, wheezing, cough, and chest tightness. Asthma is the second leading cause of death from chronic respiratory diseases and is a significant global health issue affecting all age groups [3, 4]. Research into the etiology and mechanisms of asthma has always been a focus, with genetic and environmental factors playing complex roles in asthma.

Considerable evidence suggests that the relationship between temperature and asthma typically follows a "J" or "U" shaped curve, with both low and high temperatures potentially exacerbating asthma symptoms [5, 6]. Additionally, limited research indicates that temperature fluctuations are also significant factors in the onset of asthma, with a higher diurnal temperature range (DTR) being associated with the risk of asthma hospitalization [7–9]. There is also evidence that both high and low DTR are associated with the occurrence of asthma [10]. However, a study indicated that a high DTR played a protective role in winter asthma hospital treatment in South Korea [11]. The variation in epidemiological evidence is attributed to differences in geographical and meteorological conditions, urban settings, population, and seasonal heterogeneity [12]. The existing research mainly focuses on meteorological factors and childhood asthma. However, asthma is a disease with a significant impact on the entire population. The evidence linking hospitalization of adult asthma patients to meteorological changes is limited. Studies on the impact of seasonal temperature variations on asthma are also scarce.

Asthma animal models play a crucial role in researching the mechanisms of asthma and corroborate epidemiological evidence [1, 13]. Nonetheless, many studies have failed to establish the threshold at which meteorological factors affect asthma. Temperature exposure affects a wide range, impacting not only the population directly but also interacting with allergens and pollutants, increasing the risk of asthma onset [14, 15]. Due to these complexities, future research will require more systematic studies to delve into the mechanisms underlying the impact of temperature on asthma attacks. Effective asthma management and preventive measures are crucial for controlling asthma.

Therefore, this study utilizes asthma hospitalization data from Lanzhou, China, and employs the DLNM to investigate the effects of temperature and DTR on asthma hospitalization during both cold and warm seasons. The aim is to understand whether temperature and DTR have differential effects on asthma in different age and sex groups and to uncover new epidemiological evidence of their association. This will contribute to the development of asthma prevention strategies and provide new recommendations for future research.

## Materials and methods

### Study area

Lanzhou is the capital of Gansu Province, situated in the geographic center of mainland China (Figure S1). It lies between 102°36' to 104°35' east longitude and 35°34' to 37°00' north latitude, marking the transitional zone from the Qinghai-Tibet Plateau to the Loess Plateau. Lanzhou, in the western region of China, is a significant node city along the Silk Road Economic Belt and experiences a typical continental temperate monsoon climate due to its distance from moist oceanic airflows. Winter is long and cold, while spring and summer feature moderate temperature variations. The administrative area of Lanzhou includes 5 districts and 3 counties, covering a total area of 13,200 square kilometers. As of the end of 2022, the city had a resident population of approximately 4.4 million people.

### Data collection

We collected inpatient data from all public hospitals in Lanzhou City between 2013 and 2020. We filtered and categorized diseases based on the International Classification of Diseases, Tenth Revision (ICD-10) codes. Additionally, we filtered the data based on administrative regional codes and residential information to include only residents of Lanzhou. We further stratified the cases of respiratory diseases by sex (male and female) and age groups (<15 years, 15–65 years, ≥65 years) to investigate factors related to different age and sex groups.

Hourly temperature and relative humidity data were obtained from meteorological stations of the China Meteorological Data Service Center (http://data.cma.cn/). These data underwent rigorous quality control and validation procedures, managed by professional meteorological monitoring personnel, to ensure data integrity and accuracy. To enhance data reliability further, a neighboring date mean interpolation method was employed to fill in missing data and eliminate duplicate data and outliers. Additionally, hourly concentration data for standard air pollutants were collected from the National Urban

Air Quality Real-time Publishing Platform (https://air.cnemc.cn:18007/). This dataset includes daily averages of inhalable particulate matter, sulfur dioxide, and nitrogen dioxide levels. These data were used to correct and account for the impact of air pollution on the research. Strict quality control measures were implemented during data collection and processing to ensure the accuracy and credibility of these data.

## Methods

Statistical descriptions were performed on hospital admissions for asthma, meteorological indicators, and concentrations of air pollutants during the study period. These indicators encompassed mean values, standard deviations, minimum and maximum values, and quartiles (P25%, P50%, P75%). In this research, temperature and DTR were considered as the primary focal factors. The DTR is the difference between the highest and lowest temperatures within a day. The seasons were divided into the warm season (April to September) and cold season (October to December, January to March) for seasonal analysis [16]. Additional factors like relative humidity and air pollutants were incorporated into the model as confounding variables. Spearman rank correlation analysis was employed to investigate the relationships between variables. Correlation coefficients above 0.7 indicate a strong correlation, which may indicate a multicollinearity problem and should be avoided [16]. Given that similar studies have already demonstrated the continuous and delayed nonlinear effects of temperature and DTR on asthma, and research has shown that the impact of high DTR is usually immediate and delayed, while the influence of low temperatures can persist for several days. Thus, we introduced a maximum lag of 21 days to capture the delayed nonlinear effects between daily mean temperature, temperature variation, and hospital admissions for specific asthma conditions. In this study, a distributed lag nonlinear model was employed to analyze the relationship between daily mean temperature, DTR, and the daily number of asthma hospitalizations. Since daily asthma hospitalizations are considered infrequent events, their distribution approximated a Poisson distribution. To address the issue of overdispersion, this study utilized a distributed lag nonlinear model with a Poisson distribution to assess the association between daily mean temperature, DTR, and asthma hospital admissions. The constructed model is as follows:

$$
\begin{aligned}
&Log[E(Yt)] = \alpha + \beta MeanTem_{t,l} \\
&+ ns(PM_{10t},\ df) + ns(SO_{2t},\ df) \\
&+ ns(NO_{2t},\ df) + ns(RHt,\ df) \\
&+ ns(Time_t, df) + Dow + Holiday
\end{aligned}
$$

$$
\begin{aligned}
&Log[E(Yt)] = \alpha + \beta DTR_{t,l} + \beta MeanTem_{t,l} \\
&+ ns(PM_{10t},\ df) + ns(SO_{2t},\ df) \\
&+ ns(NO_{2t},\ df) + ns(RH_t,\ df) \\
&+ ns(Time_t, df) + Dow + Holiday
\end{aligned}
$$

In the equation, $Y_t$ represents the number of asthma hospitalizations on the t day; α denotes the intercept; $MeanTemp_{t,\ l}$ represents the cross-basis matrix of temperature and lag days. $DTR_{t,\ l}$ represents the cross basis matrix of DTR and lag days. $\beta$ represents the coefficient of the cross matrix; $l$ is the lag in days; Time accounts for long-term time trends and seasonal patterns. $RH_t$ represents the relative humidity on the t day. $PM_{10t}$ represents the concentration of inhalable particulate matter in the air on the t day. $SO_{2t}$ represents the concentration of $SO_2$ on the t day. $NO_{2t}$ represents the concentration of $NO_2$ on the t day. The variable DOW is used to control for the effect of the day of the week, while the variable Holiday is used to control for the effect of holidays. A natural cubic spline function is utilized to control for other factors. To determine the degrees of freedom for selecting potential covariates, we consider a combination of Q-AIC values and relevant literature to make an informed decision [17, 18]. The degrees of freedom for the long-term trend variable time are set as 7 per year. For relative humidity and air pollutants, the degrees of freedom are specified as 3.

In this study, the model was developed using the "dlnm" package in R software (version 4.3.0, www.r-project.org). Sensitivity analysis of the model was conducted by varying the degrees of freedom for relative humidity (df=3–5), maximum lag days (df=21–23), air pollutants (df=3–5), and time (df=6–8).

## Result

Table 1 presents an exposition of hospital admissions for asthma, pollutant concentrations, and meteorological variables from 2013 to 2020. Over the course of this comprehensive study period, a total of 15,484 admissions for asthma were meticulously documented. These admissions comprised 6,421 male and 9,063 female patients, stratified further into 2,087 cases for children aged 0–14, 8,750 cases for adults aged 15–64, and 4,647 cases for elderly individuals aged≥65. The DTR demonstrated substantial variation during the study period, spanning from 0.9 °C to 26 °C. The daily average values for temperature, relative humidity (RH), and DTR were 11.13 °C, 51.19%, and 11.70 °C, respectively. Furthermore, pollutant concentrations, including $PM_{10}$, $SO_2$, and $NO_2$, were recorded with corresponding values of 114.65 μg/m³, 21.64 μg/m³, and 45.89 μg/m³, respectively, reflecting air quality during the study period. During the cold seasons, there were 7,811 admissions for asthma, while the warm seasons accounted for 7,673 admissions. This meticulous

**Table 1** Descriptive analysis of hospital admissions for asthma, air pollution, and meteorological factors in Lanzhou City

| | Mean (SD) | Min | P25% | P50% | P75% | Max |
|---|---|---|---|---|---|---|
| Hospital admissions (number of cases per day) | | | | | | |
| Asthma | 5.30(3.87) | 0 | 2 | 5 | 7 | 52 |
| Sex | | | | | | |
| Female | 3.10(2.52) | 0 | 1 | 3 | 5 | 27 |
| Male | 2.20(2.00) | 0 | 1 | 2 | 3 | 25 |
| Age | | | | | | |
| 0–14 | 0.70(1.22) | 0 | 0 | 0 | 1 | 14 |
| 15–64 | 3.00(2.71) | 0 | 1 | 2 | 4 | 39 |
| ≥65 | 1.60(1.57) | 0 | 0 | 1 | 2 | 11 |
| Season | | | | | | |
| Warm | 5.24(3.98) | 0 | 2 | 5 | 7 | 52 |
| Cold | 5.36(3.75) | 0 | 2 | 5 | 8 | 20 |
| Air pollutant concentration | | | | | | |
| $PM_{10}$ μg/m$^3$ | 114.65(83.11) | 16.00 | 70.00 | 98.78 | 136.21 | 1484.54 |
| $SO_2$ μg/m$^3$ | 21.64(14.47) | 3.54 | 10.86 | 17.57 | 28.60 | 115.51 |
| $NO_2$ μg/m$^3$ | 45.89(17.95) | 6.32 | 34.00 | 44.56 | 54.63 | 146.6 |
| Meteorological measurement data | | | | | | |
| Temperature (°C) | 11.13(9.88) | -12.3 | 2.23 | 12.6 | 19.78 | 30.4 |
| Relative humidity (%) | 51.19(15.28) | 11.71 | 40.00 | 51.85 | 62 | 96.09 |
| DTR | 11.70(4.24) | 0.9 | 8.70 | 11.70 | 14.64 | 26 |

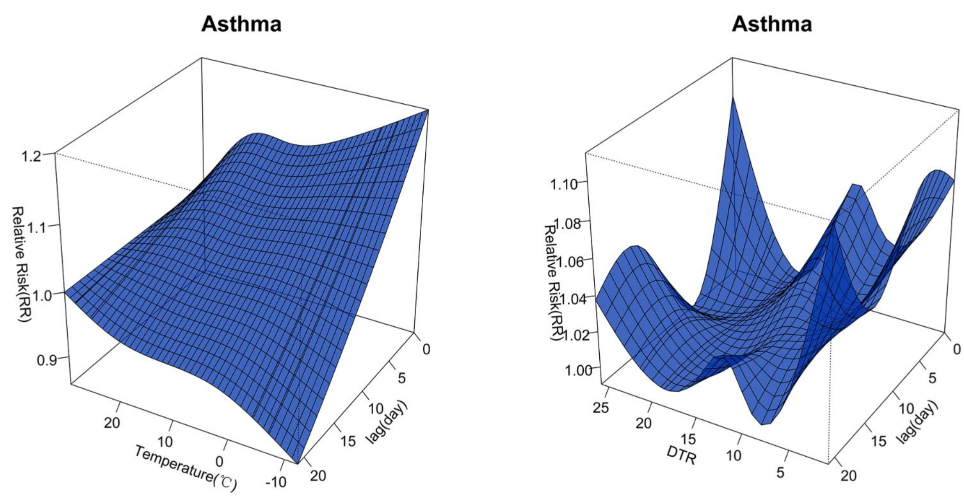


**Fig. 1** 3D plots of daily mean temperature and diurnal temperature range in relation to the risk of asthma hospitalization

dataset forms a crucial foundation for in-depth research and analysis in the field of respiratory health and environmental epidemiology. Figure S1 shows the geographical location of Lanzhou and meteorological monitoring stations in the urban area.

The 3D plot depicted in Fig. 1 illustrates the exposure-lag response association between daily mean temperature, DTR, and hospitalization for asthma. The exacerbating effect of low temperatures on the risk of asthma hospitalization is immediate. On the day of exposure, the RR value reached its maximum when the temperature was at its lowest, at 1.2010 (95% CI: 1.1464, 1.2580). And it also exhibits a lagged effect. Both high and low DTR can increase the risk of asthma hospitalization. On the day of exposure, the RR values were 1.0379 (95% CI: 1.0002, 1.0770) and 1.0327 (95% CI: 1.0083, 1.0577) when the DTR was 4.9 °C and 13.9 °C, respectively. Figure S2 shows Spearman correlation of meteorological factors and air pollutants. Figure S3 displays time series plot of asthma admissions, DTR, and daily mean temperature.

Figure 2 displays the cumulative effect curves of temperature and DTR on the risk of asthma hospitalization at lag periods of 7, 14, and 21 days. The cumulative lag effect curve for daily mean temperature also demonstrates that low temperatures can exacerbate the occurrence of asthma. The cumulative exposure-response curve for DTR in relation to asthma hospitalization takes on a “W” shape, and it is statistically significant between

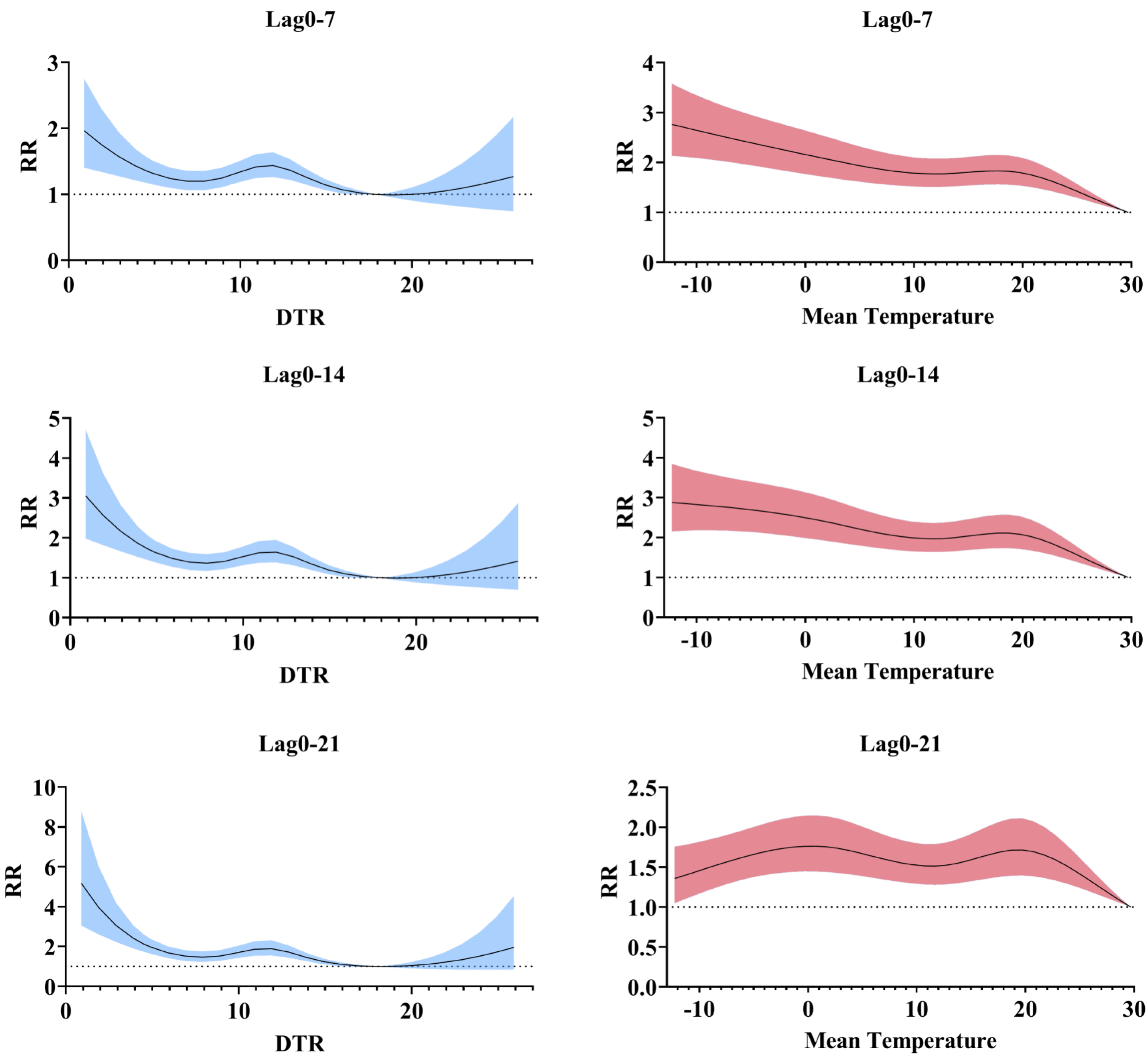


**Fig. 2** Exposure-response curves for the cumulative relative risk of hospital admissions for asthma at lag0-7, lag0-14, and lag0-21 in relation to daily mean temperature and diurnal temperature range

0.9 °C and 17.9 °C, showing an increasing trend as DTR rises. In the cumulative lag analysis, it was observed that the daily mean temperature reached its lowest at -12.3 °C, with a relative risk of 2.8612 (95% CI: 2.1433, 3.8200) for lag0-14. When the DTR was 0.9 °C, the relative risk for lag0-21 was 5.1785 (95% CI: 3.0494, 8.7940).

Figure 3 illustrates the relationship between hospital admissions for asthma and daily mean temperature in different seasons, as well as in various population subgroups. The results indicate that during warm seasons, lower temperatures are associated with a higher risk of asthma hospitalization. At 1.7 °C with a lag0-21, the relative risk reaches its highest point at 2.9798 (95% CI: 1.1154, 7.9606), and this relationship is statistically significant within the temperature range of 1.7 °C to 22.7 °C. A similar trend is observed in males and adults aged 15–64. For females and individuals aged 65 and older, statistical significance is found within the temperature ranges of 10.7–23.7 °C and 9.7–21.7 °C, respectively. However, the overall trend shows that the risk decreases with higher daily mean temperatures. In children aged 0–14, hospitalization risk is statistically significant within the temperature range of 12.7–18.7 °C.

In the cold seasons, there is a significant increase in the risk of asthma hospitalization for the overall population, and this increase is more pronounced than in the warmer seasons. Females and older individuals have a significant risk of asthma hospitalization during the colder season.

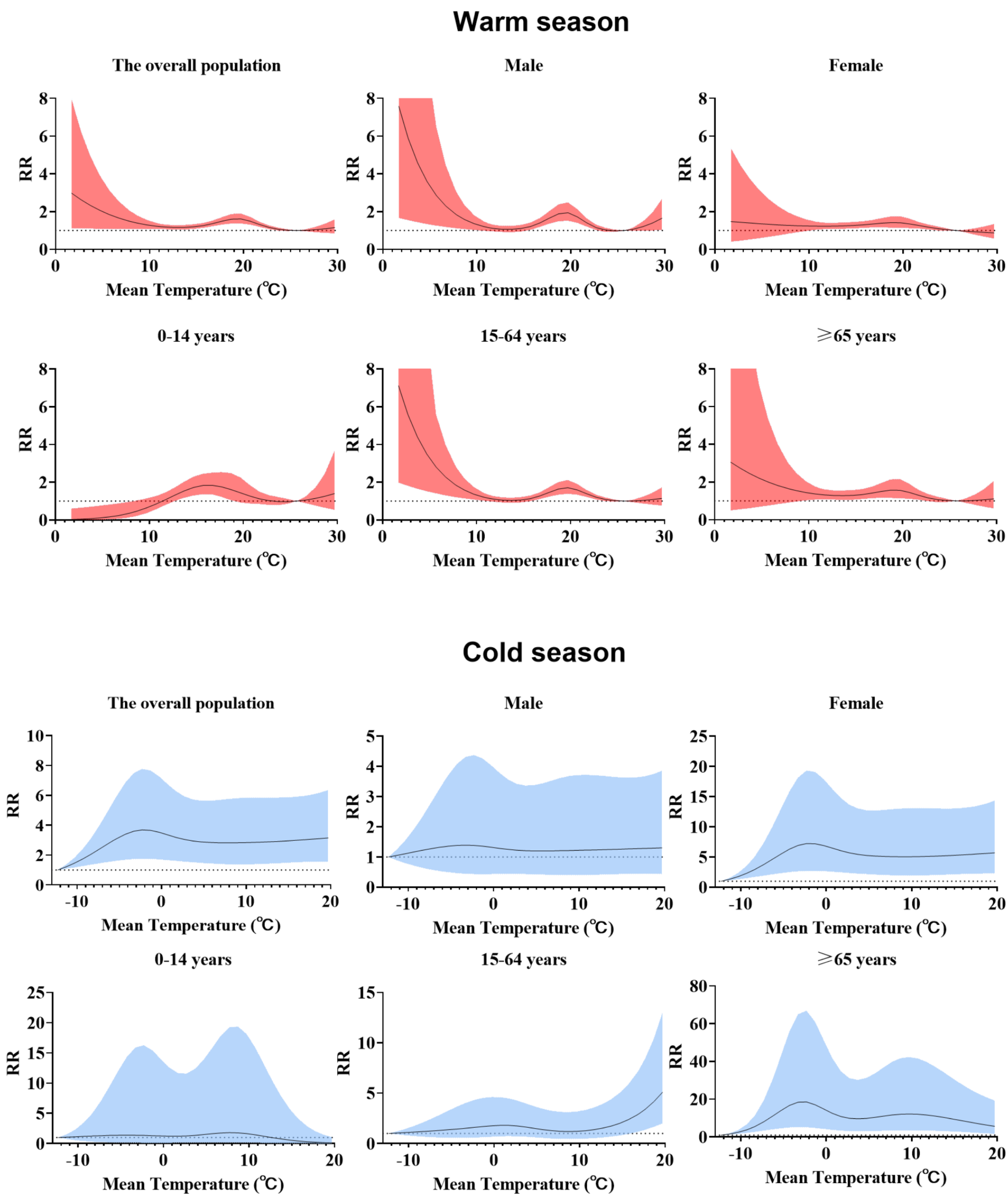


**Fig. 3** Exposure-response curves of cumulative relative risk for asthma hospital admissions in relation to daily mean temperature, divided into cold and warm seasons, including different sex and age groups, at lag0-21

For adults aged 15–64 during the cold season, the risk of asthma hospitalization is significant within the temperature range of 16.7–19.7 °C.

Figure 4 depicts the relationship between hospital admissions for asthma and DTR in different seasons, as well as in various population subgroups. The results show that during the warmer seasons, lower DTR is associated with a higher risk of asthma hospitalization.

In males, there is a significant risk of asthma hospitalization both in low DTR (0.9–6.9 °C) and high DTR (16.9–21.9 °C) conditions. Adults aged 15–64 exhibit a significant risk of asthma hospitalization when DTR is in the range of 0.9–11.9 °C and 17.9–21.9 °C. Children aged 0–14 have a significant risk of asthma hospitalization when DTR is between 12.9 and 17.9 °C.

During the colder seasons, DTR significantly increases the risk of asthma hospitalization for the overall population when it is below 15.3 °C. Children aged 0–14 have a significant risk of asthma hospitalization when DTR between 4.3 and 17.3 °C. For adults aged 15–64, there is a significant risk of asthma hospitalization when DTR is high, particularly in the range of 18.1–25.3 °C.

The sensitivity analysis, as shown in Figures S4 and S5, did not yield significant changes when altering the degrees of freedom, indicating the robustness and stability of our model. Figure S6 provides a graphical

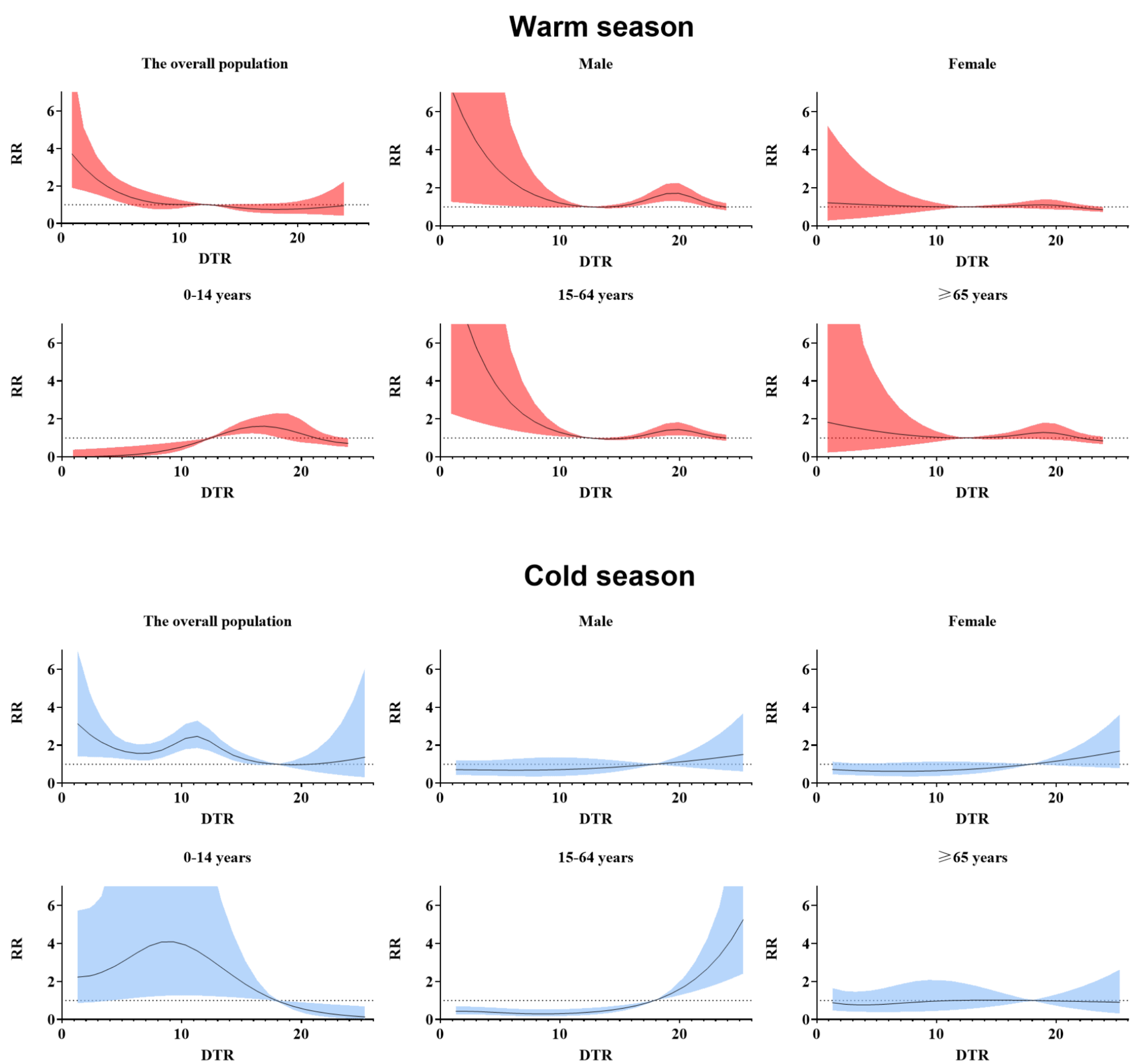


**Fig. 4** Exposure-response curves of cumulative relative risk for asthma hospital admissions in relation to DTR, divided into cold and warm seasons, including different sex and age groups, at lag0-21

representation of the potential interaction effects between DTR and daily mean temperature on asthma hospitalizations within the population, highlighting the complex interplay between these two environmental factors.

## Discussion

Previous research has mainly focused on the relationship between temperature and asthma. There has been relatively little research on the DTR, and there is also limited research demonstrating the relationship between meteorological factors in different seasons and the hospitalization risk of asthma for the general population. We explored the impact of temperature and DTR on the hospitalization risk of asthma in the population, considering sex, age, and seasonal stratification. Our results provide new insights into the influence of meteorological factors on asthma.

Low temperatures have an immediate effect on asthma attacks in the general population and also exhibit a certain degree of lag effect. As temperatures rise, the hospitalization risk for asthma gradually decreases, indicating that high temperatures may have a certain degree of alleviating effect on asthma symptoms. Previous studies have already confirmed that cold temperatures may trigger asthma attacks, which is consistent with our observation results. A study in Shanghai found that the lower the temperature is, the higher the risk of asthma hospitalization, with the effect of cold being both immediate and persistent [19]. A study found a "J" shaped relationship between temperature and asthma, with the lowest mortality temperature being 21.3 °C [5]. Few studies have focused on the analysis of the entire population in different seasons. Children are considered a more vulnerable group, but asthma in adults also has a significant negative impact on their quality of life and health [20]. Furthermore, the risk of asthma attacks may vary in different seasons and weather conditions [21]. Therefore, studying and understanding the association between asthma and meteorological conditions in the entire population is crucial for better identifying vulnerable groups and providing early prevention for asthma patients.

During the warm season, a similar pattern is observed, with relative risk decreasing as the temperature rises. Both males and females, as well as adults and the elderly, exhibit similar trends. A study in Bangladesh confirmed that in a warm climate, a decrease in temperature affects the occurrence of asthma [22]. In the warm season, higher temperatures increase the risk of childhood asthma (RR: 1.931, 95% CI: 1.191, 3.128) [23]. Children, females, and the elderly are generally more sensitive to temperature changes due to physiological factors. However, social reasons often lead to these vulnerable groups being protected by their caregivers and having a strong sense of self-preservation [24]. Hospitalized individuals are typically those with more severe illnesses, introducing a certain bias [19]. Throughout the entire cold season, the relative risk of exacerbating asthma in the population is generally higher. Females and the elderly are more prone to asthma exacerbations during the cold season. In contrast, asthma exacerbations in adults occur during higher temperatures. Similar to our findings, a study in Finland demonstrated that cold weather has an impact on asthma hospitalizations across all age groups (RR: 2.348, 95% CI: 1.026, 5.372) [25]. One study showed that adults are more likely to be exposed to high temperatures, while the elderly (≥65 years old) are more likely to be exposed to cold [26]. The exacerbation of asthma in adults during higher temperatures may be related to outdoor work, allergens, and other factors [27]. For the entire population, we found that the risk of asthma hospitalization is higher during the cold season compared to the warm season. There is also evidence indicating that the cumulative relative risk of asthma during heatwaves is 1.06 (95% CI: 1.00-1.13), while during cold snaps, it is 1.17 (95% CI: 1.05–1.30) [28]. A systematic review, including 26 studies, found an association between the cold season (1.03, 95% CI: 1.01, 1.05) and an increased risk of asthma [29]. In Lanzhou, the temperature remains at a lower level throughout the entire cold season, and the air is dry and cold, which can be irritating and trigger asthma. The increase in asthma during the cold season may be due to temperature inversions [30]. In winter, there is a higher prevalence of respiratory diseases like influenza and the common cold. If asthma patients become infected with respiratory viruses, their immune systems weaken, making the respiratory tract more sensitive and exacerbating asthma symptoms, leading to an increased need for hospitalization. During the winter, people tend to engage in indoor activities in warm and enclosed spaces, which may lead to inadequate ventilation and exposure to potential indoor pollutants, further exacerbating asthma symptoms [27]. The interaction between temperature and DTR further complicates asthma risk assessment. During cold seasons, the combination of low temperatures and high DTR can lead to a more vulnerable respiratory system, as the airways are more likely to be damaged when coping with drastic temperature changes, further increasing the risk of asthma. Conversely, in warm seasons, the combination of high temperatures and high DTR can also significantly increase asthma hospitalization rates.

Temperature variations have an impact on the increased risk of asthma hospitalization, both in adults and children [3, 7, 31, 32]. Our study found that high and low DTR both have immediate and sustained effects on the risk of asthma hospitalization. Cumulative lag exposure curves show that in the warm season, both low and high DTR increases the risk of asthma hospitalization in males and adults aged 15–64. In the warm season, high DTR increases the risk of asthma hospitalization in children aged 0–14. A study also showed that high DTR in the warm season increases the risk of acute asthma attacks in children (RR: 1.146, 95% CI: 1.010, 1.300) [23]. Another study demonstrated that DTR has a greater impact on males, both in children and adults [20]. There is an association between meteorological fluctuations and childhood asthma hospitalization rates. Parents may be more vigilant when the temperature rapidly fluctuates, which may help reduce childhood asthma hospitalization rates [33]. During the cold season, we observed that low DTR also increases the risk of asthma hospitalization. We observed a correlation between DTR and childhood asthma hospitalization risk. Similar to our results, a study in Shanghai also showed that in the cold season, high DTR appears to have a greater impact on childhood asthma [34]. Under low DTR conditions, temperature fluctuations are smaller, and the respiratory system may gradually lose its adaptability to these changes, leading to reduced respiratory stability. Low DTR may result in the retention of particles and pollutants, increasing asthma patients' exposure to other risk factors.

Temperature and temperature changes can have an impact on the respiratory system through direct or indirect pathways, thus altering airway inflammation responses, respiratory damage, and triggering airway hyperresponsiveness. Studies in Australia [34] and China [3] have experimentally shown that an increase in DTR leads to a decrease in peak expiratory flow (PEF), increased respiratory symptoms, and the occurrence of asthma. Temperature plays a critical role in regulating the immune system. Temperature changes may trigger an imbalance in Th1/Th2 cell-mediated immunity. Furthermore, extreme temperatures and temperature fluctuations beyond the body's regulatory adaptability may disrupt immune system function, thereby triggering inflammatory responses in the body [1]. On the other hand, recent animal research has found that transient receptor potential (TRP) channels play a significant role in regulating temperature stimuli [13, 35]. TRP ion channels play a key role in sensing and transmitting temperature signals and can be activated by extreme temperatures, leading to the excitation of airway sensory nerves, which may result in abnormal physiological and pathological responses in the respiratory system [1]. In summary, the impact of temperature and temperature changes on the respiratory system is multifaceted, involving various aspects such as immune regulation, immune function, airway inflammation responses, and neural regulatory mechanisms.

According to our knowledge, this study is one of the few research studies that have investigated the impact of DTR on asthma hospitalization risk in the entire population. However, our study still has some limitations. In our study, exposure assessment was primarily based on outdoor weather station data, and we could not obtain indoor data. Winter heating may lead to increased dryness of indoor air, and significant fluctuations in indoor-outdoor temperatures may also influence asthma [3]. Due to the limitations of epidemiological research, we cannot completely avoid biases [36]. In future studies, attempting to use individual-level exposure data in place of weather station monitoring data could be considered. It is challenging to control individual-level factors in the study. We can only examine the correlation between weather and asthma rather than a causal relationship. There is a lack of information on several other important factors related to asthma risk, such as allergens and genetic susceptibility. Our study used data from a single city, and while it represents a highly representative provincial capital city, it still limits the generalizability of our research to other regions with different climates and socioeconomic development. Different environmental climates and levels of urban development could lead to variations in research results. Future research should continue to assess the impact of temperature and DTR on asthma.

## Conclusion

This study reveals the complex relationship between temperature and DTR and the risk of asthma hospitalization. It finds that low temperatures immediately increase the risk but also exhibit a lag effect, while both high and low DTR can raise the risk of asthma hospitalization. Temperature is associated with asthma hospitalization risk in different seasons and subgroups of the population. Lower temperatures are related to higher asthma risk in the warm season, while the risk significantly increases in the cold season, especially in females and older individuals. Overall, as temperatures rise, the risk of asthma hospitalization decreases. In the warm season, both low and high DTR conditions show significant asthma hospitalization risk for males and adults aged 15–64. Children also display noticeable risk within specific DTR ranges. In the cold season, lower DTR increases the risk of asthma hospitalization in the general population. However, in children and adults aged 15–64, an increase in DTR is observed to significantly raise the risk of asthma hospitalization.

**Abbreviations**

| | |
|---|---|
| DTR | Diurnal temperature range |
| DLNM | Distributed lag non-linear models |
| RR | Relative Risk |
| Q-AIC | Quasi Akaike Information Criterion |
| CI | Confidence intervals |
| PEF | Peak expiratory flow |
| TRP | Transient receptor potential |

## Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-024-19737-7.

Supplementary Material 1

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The authors acknowledge the dedication and cooperation of all the participants in this study.

### Author contributions

JZ.Y, and AN.Z were involved in writing the manuscript. JZ.Y and AN.Z handled data curation. JZ.Y and MX.L created all the figures. Y.R, JY.D, and T.T made significant contributions to conceptualization and methodology and provided critical input during the review and editing of the manuscript. T.L, K.Z and XW.Z were responsible for the formal analysis and validation of the research findings. All authors have read and approved the final manuscript.

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### Data availability

The data that support the findings of this study are available from Health Commission of Lanzhou City, a government agency 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 Health Commission of Lanzhou City, a government agency. After obtaining third-party permission, data analyzed during the current study are available from the corresponding author (ruany1203@163.com) on reasonable request. Meteorological data are available at http://data.cma.cn, which is managed by the National Meteorological Information Center of China, but researchers are required to register for free at the site to access the required data. Clinical admission data are not available to the public. R version 4.3.0 software was used in this study, and licenses and other information are available at https://www.R-project.org. The software package used to construct the distributed lag nonlinear model (DLNM) is publicly available at https://cran.r-project.org.

## Declarations

### Ethics approval and consent to participate

The Institutional Review Board (IRB) at School of Public Health, Lanzhou University has waived the ethics approval and the informed consent for the study. The study adhered to the guidelines and regulations outlined in the Declaration of Helsinki. This exemption is due to the fact that the data used in the study was provided by government agencies and consented for use in this research. The data did not involve any direct or indirect identification of hospital patients' personal information. And, the waiver of informed consent has been reviewed and approved by the research ethics committee.

### Consent for publication

Not applicable.

### Competing interests

The authors declare no competing interests.

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