



Are hospital emergency department visits due to dog bites associated with ambient temperature? A time-series study in Beijing, China



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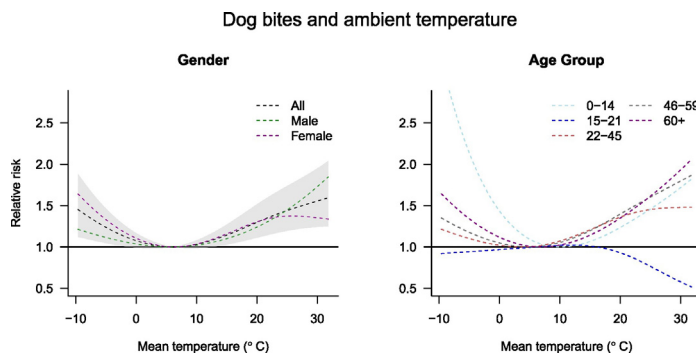
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HIGHLIGHTS

- The temperature-EDVDB association in Beijing was investigated.
- A quasi-Poisson regression with distributed lag non-linear model was employed.
- A U-shaped association was found which varied by sex and age.
- Cold effect was weaker, delayed and shorter on dog-bite risk.
- Hot effect was stronger, more immediate and lasting longer.

GRAPHICAL ABSTRACT



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ABSTRACT

Background: It is well documented that suboptimal ambient temperature is associated with cardiovascular and respiratory diseases. However, no study has examined the relation between temperature and dog bites.

Objectives: To study the association between ambient temperature and daily hospital emergency department visits due to dog bites (EDVDBs) in Beijing, China; and to explore whether the temperature-EDVDB association varies by sex and age.

Methods: Daily EDVDBs were collected from a hospital appointed for dog bites in Beijing during 2012–2014. A quasi-Poisson regression with distributed lag non-linear model (DLNM) was employed to estimate the impact of temperature on daily EDVDBs. Stratified analysis was performed to examine the temperature-EDVDB association by sex and age-groups. Sensitivity analysis was performed to check the robustness of the results by adjusting other meteorological variables and air pollutants.

Results: A total of 42,481 EDVDBs were collected, with daily cases ranged from 15 to 71. The association between temperature and EDVDBs was U-shaped, with extreme cold temperature showing a weaker, delayed and shorter effect on the risk of dog bites while the effect of extreme hot temperature being stronger, more immediate and lasting longer. Cold temperature had a greater impact on female whereas male was more sensitive to hot temperature. The temperature-EDVDB association was unapparent in the 15–21 years group. The cold effect was only

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significant in the 0–14 years group whereas all age-groups suffered from the similar heat effect except those aged 22–45 years. Adjusting other meteorological variables and air pollutants did not change the results.

Conclusions: The impact of temperature on EDVDBs is U-shaped in Beijing, China which varies by sex and age. The temperature effect is independent from other meteorological variables and air pollutants.

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1. Introduction

Globally, rabies virus results in approximate 59,000 deaths and above 2 million disability-adjusted life-year (DALY) loss each year (Knobel et al., 2005; World Health Organization, 2016b). China has the 2nd highest human rabies cases in the world, where in 2014 it remained the 16th most common and 3rd deadly infectious disease, respectively (National Health and Family Planning Commission of the PRC, 2016; World Health Organization, 2016b). Dog bites have been confirmed as the primary transmission mode of this zoonotic disease, contributing to >99% of human infections (World Health Organization, 2013). With >80 million dogs registered, China has recently become the country with the highest amount of homeless dogs in the world (World Health Organization, 2016a). The surge of dog population increases the risk of dog bites and the infection of rabies. Although there is no exact data of dog bites, the annual consumption of about 15 million doses of rabies vaccine, accounting for 80% of global usage, implies the health threat of this issue in China (Sun, 2013).

Numerous studies have explored the causes behind dog bites from the social and cultural dimensions, indicating the exposure risk is associated with inappropriate behaviour of humans or dogs such as encroachment on dog's territory, breed and failure to neuter dogs (Casey et al., 2014; Matthias et al., 2015; Patronek et al., 2013). Previous studies suggested that suboptimal temperature could cause mental instabilities and physical weakness in humans, which also resulted in increasing aggressiveness in mammal animals (Marai and Rashwan, 2004; Nybo et al., 2014; Watts et al., 2015). Therefore, it is hypothesized that the mental and physical decline combined with behavioural changes (e.g., longer staying outdoors and less dressing due to ambient temperature change) may increase the risk of dog bites (Lai et al., 2014; Özgünen et al., 2010; Yeh et al., 2012).

There are convincing evidence with regard to the impact of ambient temperature on the mental/behavioural abnormalities of humans and the resulted accidents or injuries (Lee et al., 2014; Nitschke et al., 2013; Parsons, 2014; Xiang et al., 2014). However, no study has evaluated the association between temperature and dog bites, which account for an unneglectable proportion of external accidents and injuries in the hospital emergency system in China, particularly in Beijing where approximate 120,000 cases of dog bites were recorded in 2014 (56 cases per 10,000 population) (Beijing Center for Disease Prevention and Control, 2015; Beijing Municipal Bureau of Statistics, 2016). In this study, we aimed to assess whether hospital emergency department visits due to dog bites (EDVDBs) are associated with ambient temperature in Beijing, China.

2. Materials and methods

2.1. Data collection

Daily records of EDVDBs were collected during 2012–2014 from the Navy General Hospital of PLA, one of the largest hospitals appointed for dog bites and rabies immunization in Beijing. Daily meteorological data in the same period including mean temperature, relative humidity, wind velocity, sunshine duration and rainfall were downloaded from the China Meteorological Data Sharing Service System (<http://data.cma.gov.cn>). Daily air pollutants data in 2014 included fine particulate

matter (PM_{2.5}), sulphur dioxide (SO₂), nitrogen dioxide (NO₂) and carbon oxide (CO) were collected from the China National Environmental Monitoring Centre (CNEMC).

2.2. Data analysis

A quasi-Poisson regression with distributed lag non-linear model (DLNM) was applied to fit the temperature-lag-EDVDB association. This model has been widely used by previous studies for assessing the relationship between temperature and other human health outcomes (Gasparrini et al., 2015; Guo et al., 2011; Guo et al., 2014).

$$Y_t \sim \text{poisson}(\mu_t) \\ \text{Log}(\mu_t) = \alpha + cb(\text{Temp}_t, \text{lag} = 14) + ns(\text{Time}, df = 7 * 3) + \beta \text{DOW}_t \\ + \gamma \text{Holiday}_t + \varepsilon \tau_t$$

where Y_t is the number of EDVDBs on day t ; α is the intercept; cb is the “cross-basis” function for generating bi-dimensional exposure-lag-response relationship with 3 degrees of freedom (df) for the exposure and lag spaces, respectively (Yang et al., 2014a; Yang et al., 2014b); Temp_t is the mean temperature on day t ; “lag = 14” refers a maximum lag of 14 days being used to present the lagged effect of temperature; $ns(\text{Time}, df = 7 * 3)$ is the natural cubic spline of time with 7 df per year for controlling the seasonality and long-term trend as suggested by previous studies (Goldberg et al., 2011; Guo et al., 2014; Mugge and Hajat, 2009); DOW_t is a categorical variable for adjusting day of the week on day t ; Holiday_t is a binary variable for adjusting public holidays in China; τ_t is an autoregressive term for explaining the autocorrelations of the residuals by using the log scale of daily EDVDBs at lag days; autocorrelation function is used to determine which lag days will be added into τ_t ; β , γ and ε are the coefficients.

In this study, the relative risk (RR) of EDVDBs associated with temperature was calculated by setting the reference value at the minimum-EDVDB temperature. The cold and heat effects were defined as the RR of EDVDBs at the 5th and 95th percentile of temperature, compared with the minimum-EDVDB temperature.

Stratified analysis was performed by sex (male and female) and five age-groups (0–14, 15–21, 22–45, 46–59, and ≥60 years). The age-groups were defined by referencing the daily activity and risk of exposing to dog bites of each population in China: Children aged 14 years or below enjoy less study burden and more leisure time but with weaker mobility; those aged 15–21 years are stronger but with less free time due to enrolment of senior school and college; the population aged 22–59 years are the main labour forces who work at least 5 days per week; those aged 60 years and above belong to the older population in China who are retired and have more free time.

Sensitivity analysis was performed by changing the maximum lags from 14 to 19 days. Daily data of other meteorological variables (including relative humidity, sunshine duration, rainfall, and wind velocity) and air pollutants (including PM_{2.5}, SO₂, CO and NO₂) were fitted into the model to assess their modification effects on the temperature-EDVDB association.

All statistical analyses were performed by using the R software (version 3.3.0). The “dlnm” package was used for fitting DLNM model (Gasparrini, 2011).

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