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Original Research

Impact of meteorological factors on scarlet fever in Jiangsu province, China

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ABSTRACT

Objectives: This study aimed to examine the relationships between meteorological factors and the incidence of scarlet fever in different populations for scientific prevention strategies.
Study design: An ecological study was conducted.
Methods: The seasonal index was used to detect the seasonal pattern of scarlet fever. A generalized additive model was conducted to estimate the impact of meteorological factors on scarlet fever in different age groups in Jiangsu province.
Results: Among the 15,873 cases, the vast majority of cases (91.84%) occurred in the population between 3 and 14 years old, with an average annual incidence rate of 14.51 per 100,000, and 2.81 per 100,000 in the age group ≤2 years old. In the generalized additive model, the risk of scarlet fever increased gradually with the temperature rising in both age groups. Interestingly, with the monthly mean temperature above 20 °C, the risk of scarlet fever presented a declining trend in those aged 3–14 years, while it kept stable in the age group ≤2 years. The temperature range only showed a positive effect in the population aged 3–14 years when it was above 9 °C.
Conclusions: This study revealed the different effects of meteorological factors on scarlet fever in different populations. Surveillance and targeted preventions in the population aged 3–14 years should be enhanced during March–June and November to the following January. Meanwhile, the health education of the guardians was the key to reducing the disease in the age group ≤2 years.

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Introduction

Climate change is generally recognized as one of the most important global problems that threaten human health.[1–3] In the past decades, a great deal of research has focused on the association between climate change and public health.[4,5] The findings improved the scientificity and efficiency of combatting diseases.

Scarlet fever, an acute respiratory infectious disease caused by group A *Streptococcus pyogenes* (GAS), was one of the common fatal childhood infectious diseases in the 19th century.[6] Although it is now a mild infectious disease with good prognosis, outbreaks and increasing incidence were reported in many countries and regions in recent years.[7–12] And it is progressively becoming an important public health issue. As no vaccine is available, the prevention of scarlet fever depends largely on improving understanding of mechanisms of disease transmission and integrating multidisciplinary knowledge and data to predict the patterns of disease risk.

Meteorological factors are the host-related and pathogen-related factors influencing infectious disease. Cold exposure could cause pathophysiological responses, which may inhibit the respiratory defense and cellular and humoral immunity.[13,14] Otherwise, the temperature could also influence the stability of virus outer membrane, which possibly determines the virus survival and efficiency during the airborne transmission.[15] Evidence that climate factors affect the prevalence of scarlet fever has been presented in several studies.[16–18] Owing to the differences of the immune systems and the behavior patterns between different age groups, age may be an effect modifier for meteorological impacts on scarlet fever. However, the literature on age-specific effects of meteorological factors is lacking.

The purpose of this study is to explore the meteorological effects on scarlet fever in different age groups in Jiangsu province with a generalized additive model. The findings will provide scientific information for effectively preventing and controlling the disease.

Methods

Data source

Scarlet fever, a class B notifiable infectious disease in China, must be reported timely and directly to the Nationwide Notifiable Infectious Diseases Reporting Information System (NIDRIS). The system has been implemented formally since 2004, covering all healthcare institutions throughout China.[19] The data of scarlet fever during 2005–2015 in Jiangsu province were derived from the NIDRIS. The information about scarlet fever cases included gender, age, address, and date of onset.

Demographic data were collected from the Scientific Data Sharing Center of Public Health.[20] Monthly meteorological data for the same period in Jiangsu province were downloaded from China Meteorological Data Service Center (http://data.cma.cn), including mean temperature (°C), minimum temperature (°C), maximum temperature(°C), relative humidity (%), rainfall (mm), and sunshine duration (hours). Temperature range was calculated by the maximum temperature minus the minimum temperature to represent the variation of temperature.

Statistical analysis

Based on the immune systems and behavior patterns, scarlet fever cases were categorized into three age groups: group 1 (≤2 years old), group 2 (3–14 years old), and group 3 (≥15 years old). The following analysis was conducted with each age group, except group 3 because of its very low incidence.

Seasonal index (SI)[20,21] was calculated based on the following formulas to show the seasonality of scarlet fever in different age groups:

$$\overline{x}_j = \frac{\sum_{i=2005}^{2015} x_{ij}}{11}$$

$$\overline{x} = \frac{\sum_{i=2005}^{2015} \sum_{j=1}^{12} x_{ij}}{132}$$

$$SI_j = \frac{\overline{x}_j}{\overline{x}}$$

where i denotes year from 2005 to 2015, j denotes month from January to December, x_{ij} denotes the number of cases in month j of year i, $\overline{x}_j$ denotes the average cases of month j in the study period, $\overline{x}$ denotes monthly average cases in the study period, and SI_j denotes the SI of month j.

Then, Spearman's correlation coefficients (r_s) were calculated between the meteorological variables and scarlet fever in each age group. To overcome multicollinearity, correlation analysis was also conducted between meteorological factors. If the absolute value of r_s (i.e. $|r_s|$) between variables was >0.7, the variable strongly associated with the disease was considered in the generalized additive model (GAM).[22]

GAM based on Poisson distribution was used to access the effects of meteorological variables on scarlet fever in each age group.[23] A penalized smoothing spline was used to adjust long-term and seasonal trend, and degrees of freedom was determined by generalized cross-validation.[17,22] Finally, a core GAM was specified as follows:

$$\log[E(Yt)] = \alpha + s(tl) + s(ts) + s(\text{meteorological variables})$$

where Yt is the monthly number of cases in each age group, $E(Yt)$ means the expected value for Yt, α denotes the model intercept, $s(\ )$ indicates the penalized smoothing splines, tl represents the time to adjust long-term trend, ts represents the time to adjust seasonality, and meteorological variables denote the final optimal explanatory variables in each age group.

All analyses were performed in R (version 3.3.0). GAMs were fitted using the 'mgcv' package.[24] Statistical significance was defined as $P < 0.05$.