The Influence of Meteorological Factors on The Incidence of Human Brucellosis in Baotou City in Inner Mongolia

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Abstract

The objectives of this study are to explore the meteorological factors associated with the incidence of brucellosis. The monthly incidence data of brucellosis and monthly average meteorological data in Baotou City of Inner Mongolia Autonomous Region were collected, and the DLNM model was used to explore the influence of meteorological factors on the incidence trend of brucellosis. The results of this study showed that from 2011 to 2020, a total of 7001 human brucellosis cases were reported in Baotou City. There was an obvious incidence peak from March to June each year. The seasonal fluctuation of human brucellosis transmission is significantly affected by temperature, wind speed, sunshine duration and relative humidity. 1) When the time lag was 0, RR (relative risk of brucellosis) value was above 1.00 no matter how the temperature changed, and had obvious short-term effect. 2) With the increase of wind speed, RR value increased significantly. 3) With the increase of monthly sunshine duration, RR increased first and then decreased. With the increase of lag time, the RR value showed a continuous upward trend. 4) With the increase of average relative humidity, the RR value showed a continuous downward trend. The lowest RR was 0.77 (95%CI, 0.52-1.15) when the average relative humidity was 36% and the lag was 6 months. Average temperature, wind speed, sunshine duration and relative humidity had important effects on the prevalence of brucellosis.

Keywords: Brucellosis, DLNM model, Meteorological factors

Introduction

To find the influence factors of human brucellosis disease prevention and control of human brucellosis is an important way, at present about the influence factor of human brucellosis disease research most from biological factors, social factors and behavioral factors such as the Angle analysis, the seasonal change and incidence of brucellosis association study is less. The WHO statement, based on the weather and climate of epidemic of a system to provide early warning, can bring considerable benefits for the population health. In addition, seasonal analysis of the occurrence of infectious diseases is one of the main components of infectious disease prevention and surveillance, which has four potential benefits: 1) improving the understanding of host and pathogen biology and ecology; 2) Imporoving the accuracy of the monitoring system; 3) improving the ability to predict epidemics and pandemics; 4) better understanding of the long-term effects of climate change on infectious disease control. It is of great significance to find the correlation between meteorological factors and the incidence of brucellosis in different endemic areas, which is an effective means to solve public health problems. The distributed lag non-linear model (DLNM) can well explain the nonlinear delay effect of meteorological factors by considering the time dependence between exposure and outcome in the lag dimension. It has been used in the study of the association between various infectious diseases and meteorological factors.

Objective

To explore the influence of meteorological factors on the prevalence of brucellosis.

Scope of study

1. Range of study population
   People with brucellosis in 2011-2020 and meteorological data for this decade.
2. Scope of study variables
   Environmental factors (sunshine, humidity, wind speed)
3. Time frame of the study
   Region from 2011 to 2020

Materials and methods

1. Research design

The monthly incidence data of brucellosis and monthly average meteorological data in Baotou City of Inner Mongolia Autonomous Region were collected, and the DLNM model was used to explore the influence of meteorological factors on the incidence trend of brucellosis.

2. Population and Sample

Meteorological data were obtained from China Meteorological Data Network, including average temperature, monthly precipitation, monthly sunshine duration, average relative humidity and average wind speed.

3. Data collection

According to the "Standardized Management of Infectious Disease Information Reporting" issued by the National Health and Family Planning Commission of China. During the same period, the monthly meteorological data of Baotou City were obtained from the China Meteorological Data Network, including average temperature, monthly precipitation, monthly sunshine duration, average relative humidity and average wind speed.

4. Analytical statistics:

R4.1.3 was used to draw the sequence map of human brucellosis, the meteorological sequence map and the matrix scatter plot in Baotou City, and the correlation between meteorological factors and the incidence of brucellosis was analyzed. SPSS 25.0 was used to describe the mean, standard deviation and percentile of meteorological factors and the number of cases of brucellosis, and to analyze the multicollinearity diagnosis between the respective variables (meteorological factors).

Results

1. Time trend of human brucellosis and seasonal and climatic factors

The incidence sequence and meteorological factor sequence of human brucellosis in Baotou City from 2011 to 2020. Spearman correlation analysis showed that the average temperature, sunshine duration and average wind speed and the human brucellosis cases were positively correlated, the average relative humidity and human brucellosis negatively correlated with the number of cases, the difference is statistically significant, as shown in figure 1.

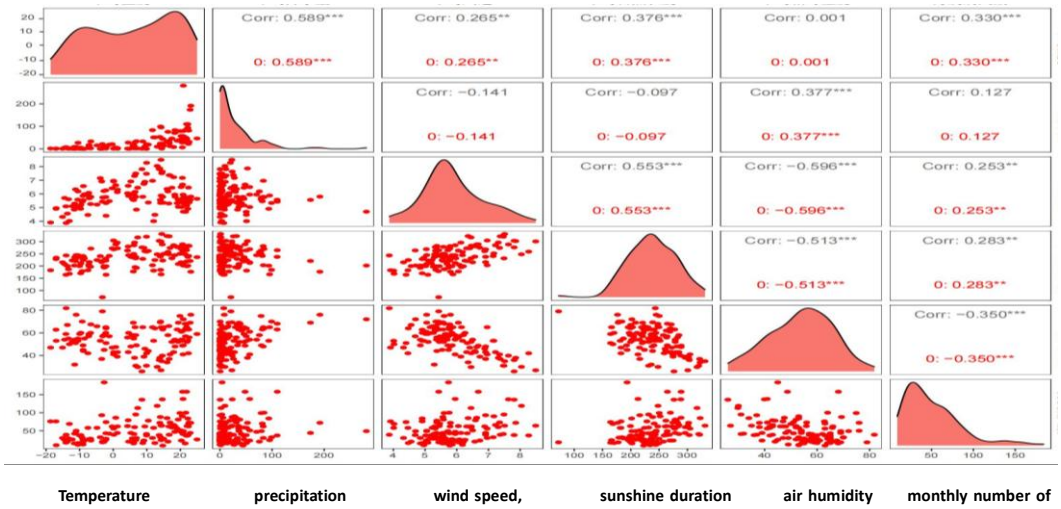

Figure 1: Scatter plot of the number of cases and the matrix of meteorological factors in Baotou City from 2011 to 2020 (Spearman correlation analysis was used for correlation, * represents P < 0.05, ** represents P < 0.01, *** represents P < 0.001)

2. Nonlinear and lag effects of climate factors on human brucellosis cases

2.1 Temperature

Figure 2: A is mean monthly temperature and the nonlinear relation between the incidence of human brucellosis and hysteresis effect of comprehensive summary. It can be seen that with the increase of lag time, the relative risk (RR) showed a trend of first decreasing and then increasing. With the increase of temperature, the RR values in different lag time shows the characteristics of different trends. The RR increased significantly when the temperature was about −11 ° C and the lag time was 0-1 month, and decreased significantly when the temperature was −11 ° C and the lag time was 3-4 months. 11B shows the separate effects of temperature and lag time at which the maximum and minimum RR values are located and the 95% confidence intervals. When the time lag was 0, the RR value was above 1.00 regardless of the temperature change, and the RR value was the largest at -11 ° C, which was 3.20 (95%CI, 1.01−4.58). When the lag time was 3 months, the RR values were all below 1.00. When the temperature is at −9 ° C and −11 ° C, the RR value shows a trend of first decreasing and then increasing with the increase of lag time. The smallest RR was 0.53 (95%CI, 0.20−0.96) at -9 ° C with a lag time of 3 months.

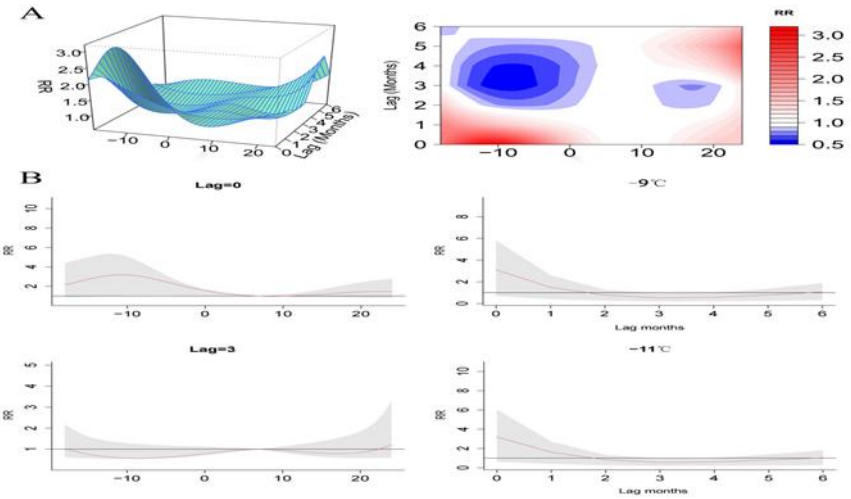

Figure 2: A: 3D rendering and contour plot of the relative risk of human brucellosis transmission with time lag and temperature. B: Plot of the effect of specific temperature and time lag on the relative risk of human brucellosis transmission (Note: red line represents average relative risk, gray line represents 95%CI)

2.2 The wind speed

The comprehensive effect of wind speed and lag time on the RR value of human brucellosis is shown in Figure 3.

The 3D rendering diagram and contour diagram show that the RR value increases significantly with the increase of wind speed. When the wind speed reaches about 5 m/s, the RR value gradually falls back to 1.00, starts to increase again when the wind speed reaches 7 m/s, and shows a downward trend again when the wind speed reaches 7.6 m/s. In addition, with the increase of the time lag, the RR values present the trend of rising and falling, first peak in the lag of 3 months. Figure 2b shows specific wind speed and the time lag of brucellosis disease the influence of the number of cases, it can be seen, when the time lag of 0 or 3 months, with the increasing of wind speed is fast, the RR values present M shape distribution, when the average wind speed 3.9 M/s, with the increase of the time lag, the RR value linear upward trend. When the average wind speed was 4.8 m/s, the RR value was always above 1, showing an inverted V-shaped distribution. When the wind speed was 4.8 m/s and the time lag was 3 months, the RR was the highest, which was 1.99 (95%CI, 1.46-2.70). When the wind speed was 3.9 m/s and the lag time was 0, the RR was the lowest, which was 0.46 (95%CI, 0.25–0.85).

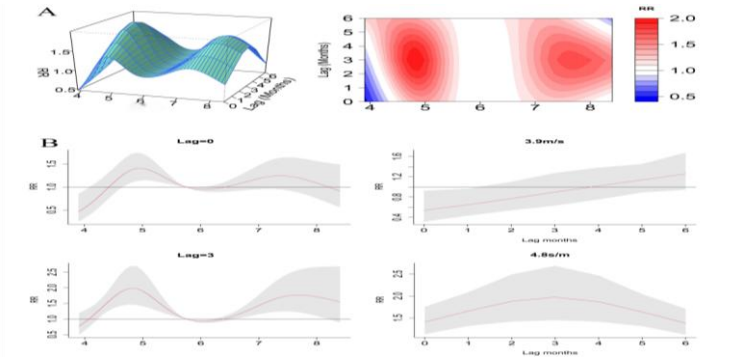

Figure 3: A: 3D rendering and contour plot of the relative risk of human brucellosis transmission with time lag and wind speed. B: Plot of the influence of specific wind speed and time lag on the relative risk of human brucellosis transmission (Note: red line represents the average relative risk, gray line represents 95%CI)

2.3 The sunshine duration in March

The comprehensive effect of time delay and monthly sunshine duration on the RR value of human brucellosis is shown in Figure 3A. With the increase of monthly sunshine duration, the RR value shows a continuous downward trend. With the increase of the time lag, the RR value after rising to decline. When the monthly sunshine duration was about 165h and the time lag was 2-4 months, the RR value increased significantly. When the monthly sunshine duration was about 329h and the time lag was 0-1 month, the RR decreased significantly. According to Figure 3B, when the time lag is 0, the RR value shows a trend of first increasing and then decreasing with the increase of monthly sunshine duration. When the time lag was 3 months, the RR values showed a W-shaped distribution. The sunshine duration in that month was 165h, and the RR showed an inverted V-shaped distribution. When the monthly sunshine duration was 165h and the lag was 3 months, the RR was the highest, which was 2.13 (95%CI, 1.52-2.99). When the monthly sunshine duration was 165h and the lag time was 0, the RR was the lowest, which was 0.68 (95%CI, 0.43-0.97).

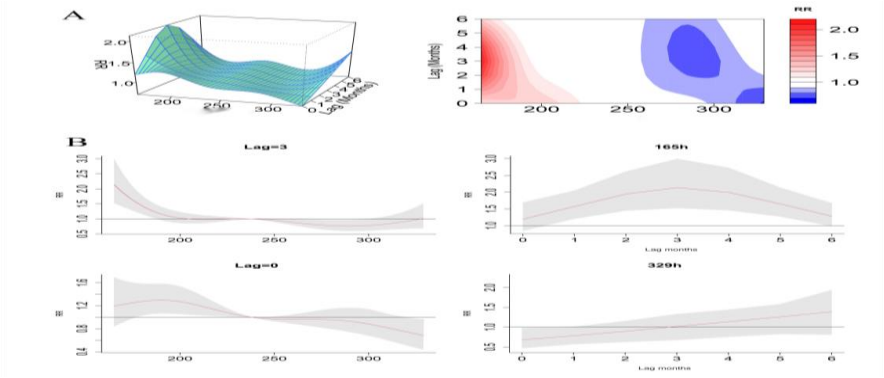

Figure 4: A: 3D rendering and contour plot of the relative risk of human brucellosis transmission for time lag and sunshine duration. B: Plot of the effect of specific duration of sunshine and time lag on the relative risk of human brucellosis transmission (Note: red lines indicate mean relative risk, gray lines indicate 95%CI).

2.4 Relative humidity

Figure 5 a shows the average relative humidity and non-linear relation between the incidence of human brucellosis and hysteresis effect of comprehensive summary. It can be seen that the RR value shows a continuous downward trend with the increase of the average relative humidity. When the average relative humidity is around 28% and the lag time is 0, the RR value increases significantly. When the average relative humidity is 75% and the time lag of 0, the RR value decreased significantly. Figure 4B shows that when the time lag is 0, the RR value shows a continuous decreasing trend as the average relative humidity increases. When the lag time was 6 months, the RR values showed a W distribution as the average relative humidity increased. When the average relative humidity was 36%, the RR value showed a trend of slowly increasing first and then rapidly decreasing with the increase of lag time. When the average relative humidity was 26%, the RR value showed a trend of continuous decreasing with the increase of lag time. When the average relative humidity was 26% and the lag time was 0, the RR was the highest, which was 1.64 (95%CI, 1.03-3.01). When the average relative humidity is 36% and the time lag for 6 months, minimum value RR, 0.77 (95% CI, 0.52-1.15).

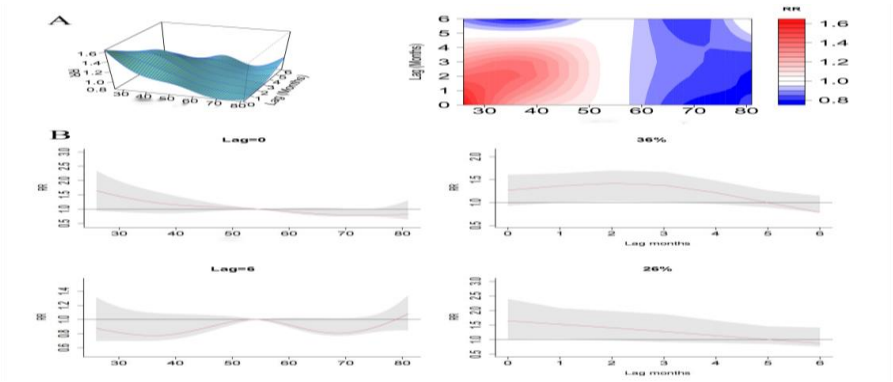

Figure 5: A: 3D rendering and contour plot of the relative risk of human brucellosis transmission with time lag and wind speed. B: Plot of the influence of specific wind speed and time lag on the relative risk of human brucellosis transmission (Note: red line represents the average relative risk, gray line represents 95%CI)

Discussion

Human brucellosis has obvious seasonal characteristics. Meteorological factors are the key factors to explain the seasonal characteristics of human brucellosis.

Temperature is closely related to many diseases, such as hand, foot and mouth disease, dengue fever and malaria. Similarly, in the present study, temperature changes had a large impact on the prevalence of human brucellosis. Temperatures above 18 ° C have a long-term promoting effect on the prevalence of brucellosis. It may be that the increase in temperature increases the development and replication of Brucella in the host, increasing the exposure frequency of susceptible animals and humans (Li Mingtao, et al., 2014). A similar conclusion was also obtained in the study of luo (Yoo EH, et al., 2021). However, this study found that when the temperature is in - 11 ° C (RRmax = 3.20, 95% CI 1.01-4.58), short period of time will also promote the popularity of brucellosis. This may be related to the restriction of livestock movement within the pens by ranchers in winter, which may cause the aggregation of Brucella. And the temperature range of brucellosis epidemic only produce short-term stimulative effect, with the increase of the time lag, brucellosis epidemic of relative risk in continues to decline, the reason of this phenomenon appears may be under the condition of winter cold temperatures, brucella and survival time and decrease (Liu Kun, et al., 2020), brucella changes over time and fewer in number Eventually reduce the brucella infection.

In addition, this study found that when the wind speed was greater than 3.9m/s, it

had a significant impact on the increase of human brucellosis cases. It may be due to the large amount of Brucella-carrying aerosols released by the farms. The increase of wind speed accelerate the spread of aerosols, quickly pollution is food and water. When sunshine time was about 165h (RRmax = 2.13, 95%CI 1.52-2.99) and relative humidity was about 26% (RRmax = 1.64, 95%CI 1.03-3.01), the relative risk of brucellosis epidemic was high. This result may be caused by the following three reasons: one, the proper sunshine time and relative humidity has significant influence on livestock heat, brucella may therefore produce and rapidly increasing. Second, most animals infected with brucellosis do not show obvious manifestations and are mainly transmitted to humans through abortion and secretions infection. With the arrival of the production season, a lot of brucella excreted into the environment, which may lead to brucella are at higher risk of exposure to cattle and people (YuanJie, et al., 2021). 3. Appropriate sunshine duration and low relative humidity create an environment suitable for the survival of Brucella, which prolongs the survival time of Brucella and increases the possibility of infection. In addition, in a dry environment, human skin may be dry and cracking, which will increase the risk of exposure. When the sunshine duration is above 260h and the relative humidity is above 58% in a month, the risk of brucellosis epidemic is reduced, because under these environmental conditions, Brucella is not suitable for survival and reproduction. Brucella has weak tolerance to high humidity and longtime light, which will limit the prevalence of brucellosis. In addition, the effects of monthly sunshine duration and average relative humidity on the prevalence of brucellosis had long-term effects and continued to weaken with the increase of lag time, and the specific mechanism needs to be further studied.

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