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Identification of weather variables sensitive to dysentery in disease-affected county of China

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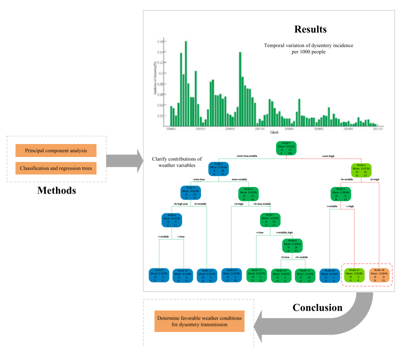
HIGHLIGHT

- Dysentery incidence shows an obvious seasonality.
- Dysentery incidence highly correlates to temperature, rainfall and humidity.
- High mini temp. with relative humidity or rainfall helps high-incidence dysentery.
- Identification results show good agreement with other studies in this aspect.
- Seeming disagreement with other researches has three reasons.

GRAPHICAL ABSTRACT



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ABSTRACT

Climate change mainly refers to long-term change in weather variables, and it has significant impact on sustainability and spread of infectious diseases. Among three leading infectious diseases in China, dysentery is exclusively sensitive to climate change. Previous researches on weather variables and dysentery mainly focus on determining correlation between dysentery incidence and weather variables. However, the contribution of each variable to dysentery incidence has been rarely clarified. Therefore, we chose a typical county in epidemic of dysentery as the study area. Based on data of dysentery incidence, weather variables (monthly mean temperature, precipitation, wind speed, relative humidity, absolute humidity, maximum temperature, and minimum temperature) and lagged analysis, we used principal component analysis (PCA) and classification and regression trees (CART) to examine the relationships between the incidence of dysentery and weather variables. Principal component analysis showed that temperature, precipitation, and humidity played a key role in determining transmission of dysentery. We further selected weather variables including minimum temperature, precipitation, and relative humidity based on results of PCA, and used CART to clarify contributions of these three weather variables to dysentery incidence. We found when minimum temperature was at a high level, the high incidence of dysentery occurred if relative humidity or precipitation was at a high level. We compared our results with other studies on dysentery incidence and meteorological factors in areas both in China and abroad, and good agreement has been achieved. Yet, some differences remain for three reasons: not identifying all key weather variables, climate condition difference caused by local factors, and human factors that also affect dysentery incidence. This study hopes to shed light on potential early warnings for dysentery transmission as climate change occurs, and provide a theoretical basis for the control and prevention of dysentery.

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1. Introduction

Global climate change generally has a negative and widespread influence on human health (Colwell et al., 1998), resulting in substantial morbidity and mortality (Patz et al., 2005). Among the various diseases affecting human health, the impact of infectious diseases is the heaviest; nearly 15 million people die annually as a direct result of infectious diseases (>25% of annual total deaths) (Morens et al., 2004). It is widely believed that climate has an important impact on the sustainability and spread of many infectious diseases (Kuhn et al., 2005). Climate change refers to change in weather variables such as temperature, precipitation, wind speed, humidity, and others (Wu et al., 2013). Climate change affects infectious diseases through impacting three epidemiological aspects: the pathogens themselves, their hosts/vectors, and transmission. Life cycle, the development and extrinsic incubation period (EIP) of pathogens may be impacted by temperature, precipitation and humidity(Wu et al., 2016). Most bacteria, viruses and parasites have certain thresholds of temperature to develop (Wu et al., 2013). For example, the spread of malaria ceases when temperature exceeds 16–33 °C due to the inability of spores to reproduce (Khasnis and Nettleman, 2005). The epidemiology of respiratory pathogens such as avian influenza A viruses is closely correlated to temperature, humidity, and atmospheric pressure. For example, the incidence of H7N9 influenza strongly correlates with temperature and relative humidity, while that of H5N1 closely correlates with temperature and atmospheric pressure (Li et al., 2015). Therefore, the impact of weather variables on different subtypes of the same disease may differ. In addition, hosts or vectors are impacted by weather variables. For example, the larvae development of certain mosquito hosts are significantly affected by temperature and precipitation (Hoshen and Morse, 2004). Climate conditions and weather variables may also impact the transmission of infectious diseases (Wu et al., 2016). For instance, the incidence of hemorrhagic fever with Renal Syndrome (HFRS) is significantly associated with meteorological factors such as temperature, precipitation, and humidity (Xiao et al., 2014). Temperature and wind are positively correlated to hand, foot and mouth disease (HFM) (Zhang et al., 2016). Diurnal temperature range is the key weather variable for childhood bacillary dysentery (Wen et al., 2016). Many researchers have shown that meteorological factors play a key role in transmission of different types of infectious diseases. Precipitation has a major impact on development of such water-borne diseases as cholera (Pascual et al., 2002). Vector-borne diseases are extremely climate-sensitive and are impacted by different weather variables (Patz et al., 2005). For example, transmission of Japanese Encephalitis is mainly affected by local minimum temperature and absolute humidity (Tian et al., 2015). The influence of weather variables on air-borne disease, including avian influenza, is also a case in point (Li et al., 2015).

Globally, China has one of the highest burdens of infectious diseases. In China, the leading infectious diseases are tuberculosis, hepatitis B, and dysentery (Zhang et al., 2007). The incidence of dysentery reported in 2009 was 20.28 per 100,000 people (Sui et al., 2010). The spatial distribution of dysentery varies widely in China; the incidence of dysentery exhibits a distinct seasonality in many areas (Ding et al., 2013; Levy et al., 2016; Li et al., 2013). It indicated that meteorological factors might play a key role in the epidemics of dysentery. Many researchers have proposed explanations for the correlation between dysentery incidence and weather variables. For example, a study in Jinan found that a rise of 1 °C in maximum temperature correlates with an approximately 11.40% increase in cases of bacillary dysentery (Zhang et al., 2008). In Botswana, the incidence of diarrheal disease has a negative relationship with precipitation in dry season (Alexander et al., 2013), while in Dhaka, Bangladesh a positive correlation between non-cholera diarrhea and rainfall above the threshold is found (Hashizume et al., 2007). Transmission of dysentery is significantly associated with humidity. For example, bacillary dysentery incidence is positively related with humidity in Beijing of China (Ma et al., 2013).

Obviously, previous researches on weather variables and dysentery mainly focus on determining correlation between dysentery incidence and weather variables. However, the contribution of each variable to dysentery incidence has been rarely clarified. Therefore, in this study, we screened out dysentery from many climate-sensitive diseases to examine its relationship with weather variables. We aimed to identify the key weather variables contributing to the incidence of dysentery. This study will provide a theoretical basis for predicting transmission of dysentery under future climate model scenarios. Thus it helps to give an early warning of potential dysentery so as to timely prevent and control it.

2. Methods

2.1. Study setting and data source

The study is designed into two steps, including screening based on literature and data integrity respectively, and correlation analysis between selected infectious diseases and weather variables.

According to incidence and distribution of dysentery, a typical study area was selected. Dysentery is the second most commonly reported infectious diseases in Guangxi Province (Liu et al., 2015). Guangxi Province is also representative in the central south area of China, in terms of dysentery incidence (Wang et al., 2006). According to existing data (2007–2011), the total number of cases of infectious intestinal diseases was 1054 in Binyang County, and the highest incidence of disease occurring for dysentery, accounting for 80.93% (Tan et al., 2013). Therefore, the Binyang County of Guangxi Province was chosen as the study area. It is usually rainy with high temperatures due to a subtropical monsoon climate in Binyang County. The distribution of rainfall is uneven, and it is more in south than in north. Summer is hot and winter is often quite warm due to high solar radiation. To verify analysis be reliable and scientific in this study, the Feidong County in Anhui Province was chosen as a comparative area, where its area and population are similar to Binyang County.

Monthly surveillance data for 16 infectious diseases during 2004–2010 at the county level were obtained from the Web-based notification system for infectious diseases, which is coordinated by the Chinese Center for Disease Control and Prevention (CDC). Data quality control was also performed by CDC (Liu et al., 2011). The infectious diseases included HFRS, dengue fever, leptospirosis, hepatitis A, influenza A, bacillary dysentery (dysentery hereinafter), influenza, Japanese encephalitis, malaria, avian influenza, typhoid fever, HFM, meningitis, plague, schistosomiasis and cholera. We calculated the monthly incidence ($\boldsymbol{i}$) of each disease as:

$$\boldsymbol{i} = a/b \times 100\% \tag{1}$$

where $\boldsymbol{i}$ is incidence of diseases, a represents the monthly number of cases of each infectious diseases and b is the size of the study population. In this study, $\boldsymbol{I}$ was used to do the statistics, i.e. $\boldsymbol{i}$ per 1000 people ($\boldsymbol{i}$/1000).

$$\boldsymbol{I} = \boldsymbol{i} \times 1000 \tag{2}$$

Population data were obtained from the sixth census by the National Bureau of Statistics of China. Climate data were obtained from the dataset developed for field observation, remote sensing data and reanalysis data that was interpolated from the Land Surface Model around the Chinese mainland during 1960–2010. In this study, weather variables included monthly average temperature (*at*), monthly average cumulative precipitation (*pre*), monthly average wind speed (*w*), monthly average relative humidity (*rh*), maximum temperature (*maxt*), and minimum temperature (*mint*). Hereinafter, we used temperature referred to monthly mean temperature, and other weather variables were similar to. Absolute humidity (*ah*) usually measured by vapor