



## Effects of dust storm events on weekly clinic visits related to pulmonary tuberculosis disease in Minqin, China



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### HIGHLIGHTS

- There is a clear link between the population dynamics of PTB and dust storms.
- The onset of PTB epidemics and dust storms occurred in almost the same mean week.
- Particulate matter may be the cause of the PTB outbreak on dust storm days.
- Reduction of the PTB epidemic was linked to improvements in the local environment.

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### ABSTRACT

Pulmonary tuberculosis (PTB) is a major public health problem in China. Minqin, a Northwest county of China, has a very high number of annual PTB clinic visits and it is also known for its severe dust storms. The epidemic usually begins in February and ends in July, while the dust storms mainly occur throughout spring and early summer, thereby suggesting that there might be a close link between the causative agent of PTB and dust storms. We investigated the general impact of dust storms on PTB over time by analyzing the variation in weekly clinic visits in Minqin during 2005–2012. We used the Mann–Whitney–Pettitt test and a regression model to determine the seasonal periodicity of PTB and dust storms in a time series, as well as assessing the relationships between meteorological variables and weekly PTB clinic visits. After comparing the number of weekly PTB cases in Gansu province with dust storm events, we detected a clear link between the population dynamics of PTB and climate events, i.e., the onset of epidemics and dust storms (defined by an atmospheric index) occurred in almost the same mean week. Thus, particulate matter might be the cause of PTB outbreaks on dust storm days. It is highly likely that the significant decline in annual clinic visits was closely associated with improvements in the local environment, which prevented desertification and decreased the frequency of dust storm events. To the best of our knowledge, this is the first population-based study to provide clear evidence that a PTB epidemic was affected by dust storms in China, which may give insights into the association between this environmental problem and the evolution of epidemic disease.

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### 1. Introduction

It is known that Asian dust storms (ADS) occurring in the spring mainly originate in the Gobi and Takla Makan deserts of Mongolia and western China, and they can be transported eastward to China (Chen et al., 2003), Japan (Fan et al., 1996; Figen Var et al., 2000), Korea (Chung and Yoon, 1996), Taiwan (Chen et al., 2004), and

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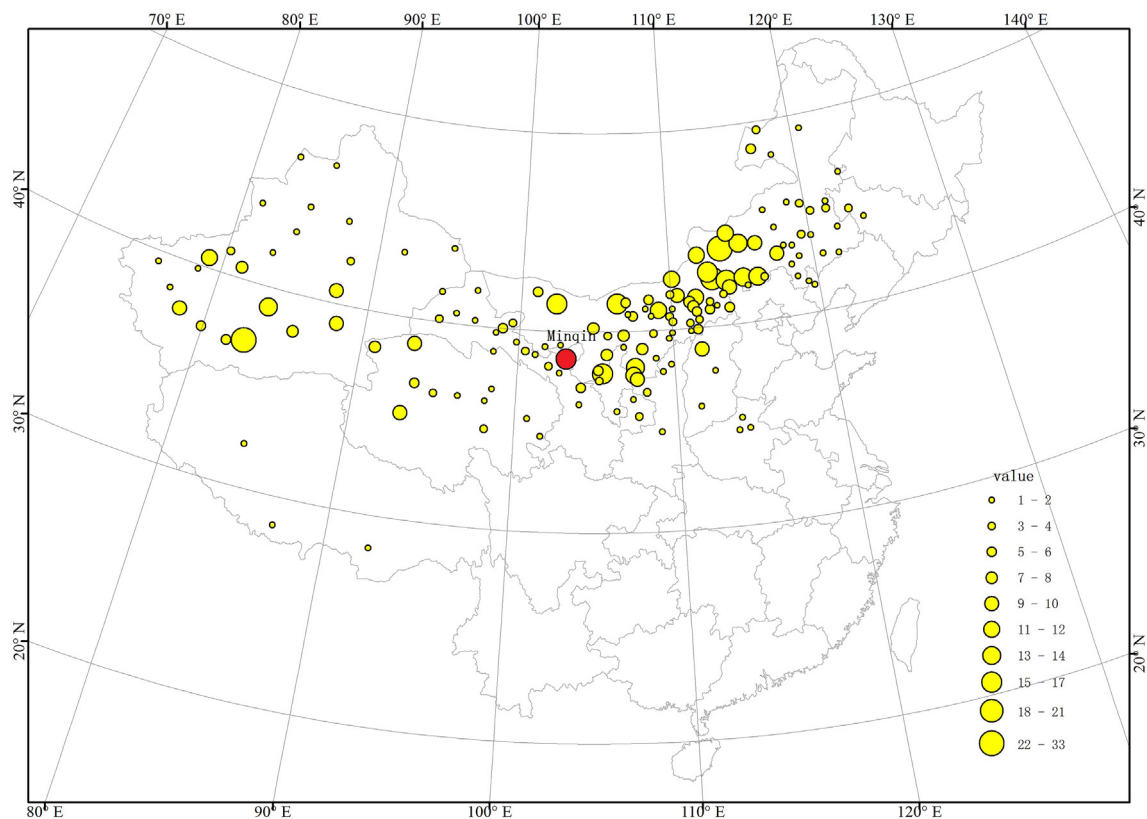
sometimes the western coast of North America (Duce et al., 1980; R. B. Husar et al., 2001). Minqin County (102.9591°E, 38.6071°N) is an administrative district in Gansu, China, which is part of the Wuwei prefecture, and its population was 300,000 people in 2006. Minqin symbolizes China's battle with desertification because this small agricultural region with 300,000 inhabitants is now threatened by the spread of the Badan Jaran and Tengger Deserts, which are two natural deserts that are gradually meeting in the middle. Its location means that dust storms are a major environmental problem in Minqin (Fig. 1). The number of severe dust storm events (visibility  $\leq 200$  m, instantaneous maximum wind velocity  $\geq 20$  m/s) each year has increased by over 10 times in the past 50 years (Qian et al., 2002, 2006). Moreover, floating dust weather events often occur in the spring and early summer.

Several studies have shown that the presence of desert dust in the atmosphere is associated with increased concentrations of cultivable bacteria, cultivable fungi, and fungal spores in downwind areas relative to the background levels, or days with clear atmospheric conditions (Chen et al., 2010; Griffin et al., 2001, 2003, 2006, 2007, Griffin et al. 2007; Ho et al., 2005; Kellogg et al., 2004; Schlesinger et al., 2006). The levels of particulate air pollution, such as total suspended particulates (TSP) (Chung and Yoon, 1996) and particulate matter with an aerodynamic diameter  $< 10$   $\mu\text{m}$  ( $\text{PM}_{10}$ ) (R.B. Husar et al., 2001; Lin, 2001; Var et al., 2000), can rise significantly in affected urban areas during dust storm periods. Based on growing evidence from epidemiological studies, increases in deleterious health effects, including respiratory diseases, have recently attracted much attention during dust storm days in downwind areas (Bell et al., 2008; Chan et al., 2008; Chang et al., 2006; Chen et al., 2004; Chen and Yang, 2005; Chien et al., 2012;

Yang et al., 2005a, 2005b). However, previous health studies have provided no consistent evidence that adverse health effects correspond to increases in particulate pollution. Using mortality data as health outcomes, two previous studies reported insignificant effects of ADS on mortality in Korea and Taiwan. Kwon et al. (2002) reported that ADSs during 1995–1998 were not associated with deaths due to cardiovascular and respiratory diseases in Seoul, Korea (Kwon et al., 2002). Hsieh and Liao (2013) reported that ADS events are seasonally-based meteorological phenomena that exacerbate chronic respiratory diseases (Hsieh and Liao, 2013).

Although relatively efficient treatments have existed for pulmonary tuberculosis (PTB) for decades, this disease remains one of the leading causes of mortality attributed to an infectious disease. PTB has affected China for centuries and it has the world's second largest tuberculosis epidemic (after India). During 2004–2012, the Centers for Disease Control (CDC) in China registered 950,000 to 1250,000 disease cases per year, where about 0.08% resulted in death (CDC, 2013). Minqin has one of the highest annual clinic visitation rates for PTB in China (Fig. 2). CDC datasets from China show that the highest annual number of clinic visits for PTB in Xinjiang province (0.193%) occurred in 2006, but the rate was 0.191% in the same year in Minqin county, which is very close to Xinjiang province. Therefore, PTB is now a major public health concern in Minqin (Yang and Men, 2008; Yang et al., 2008).

PTB is an infection of the lung caused by the bacterium *Mycobacterium tuberculosis*, which induces chronic infection with a very high rate of mortality in Chinese populations. The agent is highly contagious and person-to-person aerial transmission occurs via respiratory and throat secretions (Konstantinos, 2010). Interactions between different environmental parameters (e.g., immune



**Fig. 1.** Frequency of dust storm events in China during 2006 based on 753 atmospheric observation stations. The size of each circle represents the number of dust storm events. The red circle indicates the frequency of dust storm events in Minqin.

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