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Effects of the floods on dysentery in north central region of Henan Province, China from 2004 to 2009

Wei Ni ^{a,b}, Guoyong Ding ^c, Yifei Li ^{a,b}, Hongkai Li ^{a,b},
Qiyong Liu ^{b,d}, Baofa Jiang ^{a,b,*}

^a Department of Epidemiology and Health Statistics, School of Public Health, Shandong University, Jinan City, Shandong Province, 250012, PR China

^b Shandong University Climate Change and Health Center, Jinan City, Shandong Province, 250012, PR China

^c Department of Occupational and Environmental Health, School of Public Health, Taishan Medical College, Taian City, Shandong Province, 271016, PR China

^d State Key Laboratory for Infectious Diseases Prevention and Control, National Institute for Communicable Disease Control and Prevention, China CDC, Beijing City, 102206, PR China

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Summary *Objectives:* Zhengzhou, Kaifeng and Xinxiang, the cities in the north central region of Henan Province, suffered from many times floods from 2004 to 2009. We focused on dysentery disease consequences of floods and examined the association between floods and the morbidity of dysentery, based on a longitudinal data.

Methods: A generalized additive mixed model was conducted to examine the relationship between the monthly morbidity of dysentery and floods from 2004 to 2009 in the study areas. The relative risks (RRs) of the floods risk on the morbidity of dysentery were estimated in each city and the whole region.

Results: The RRs on dysentery were 11.47 (95% CI: 8.67–15.33), 1.35 (95% CI: 1.23–3.90) and 2.75 (95% CI: 1.36–4.85) in Kaifeng, Xinxiang and Zhengzhou, respectively. The RR on dysentery in the whole region was 1.66 (95% CI: 1.52–1.82).

* Corresponding author. Department of Epidemiology and Health Statistics, School of Public Health, Shandong University, No. 44 Wenhua Road, 250012, Jinan, PR China. Tel.: +86 0531 88382141; fax: +86 0531 88382128.

E-mail addresses: bjiang@sdu.edu.cn, bjiang2013@gmail.com (B. Jiang).

Conclusions: Our study confirms that flooding has significantly increased the risk of dysentery in the study areas. Additionally, we observed that a sudden and severe flooding can contribute more risk to the morbidity of dysentery than a persistent and moderate flooding. Our findings have significant implications for developing strategies to prevent and reduce health impact of floods.

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Introduction

Due to climate change, floods are recognized as the most frequent and devastating type of natural disasters in the world.¹ The number of global flood events doubled from 2001 to 2010. China frequently experiences natural disasters, of which flooding is the most serious.² Yellow River Basin, the second large river in China, has unique river valley topography. Climate change brought abundant rainfall and frequent storm floods to the north central region of Henan Province, where the Yellow River meandered. Consequently, the persistent and heavy precipitation led to several floods in Zhengzhou, Kaifeng and Xinxiang cities in the north center Henan Province between 2004 and 2009.^{3–7}

Floods are known to cause heavy physical damages during the initiation phase, but as floodwaters recede there are more threats to personal health and safety. Floods are associated with an increased risk for diarrheal diseases.⁸ Some studies have shown this effect that diarrheal diseases can increase in weeks or months after floods both in developing and developed countries. For example, Schwartz et al. found that in all flood-associated diarrheal epidemics (1998–2004) cholera was a predominant cause compared to control period in Dhaka, Bangladesh.⁹ In a large study undertaken in Indonesia in 1992–1993, floods were identified as a significant risk factor for diarrheal illnesses caused by *Salmonella enterica* serotype Paratyphi A (paratyphoid fever).¹⁰ A study from Germany revealed that contact with flood-water was significantly associated with onset diarrhea (OR = 5.8, 95% CI: 1.3–25.1).¹¹ In addition, an increased risk of gastroenteritis following the floods in 2000 has been reported in Lewes, England through a historical cohort study by Reacher et al.¹²

Dysentery, including bacillary dysentery and amebic dysentery as diarrheal diseases, remains a major public health problem in Henan Province. The incidence of dysentery each year ranged from 16.38 to 40.14 per 100,000 in Henan during 2004–2009,¹³ which was the second highest among the 39 species of notified infectious diseases. The health effects of floods may include increased mortality and morbidity from dysentery. Although some studies considering dysentery as a flood-related disease found that the rate of dysentery increased after floods,^{14–16} there has been no research quantifying the effect of floods on dysentery to our knowledge. The evidence on the association between floods and dysentery is far from clear. Some studies also showed that after fully controlling

for the difference with pre-flood rates and seasonality, there was no clear evidence of excesses found in dysentery risk during or after flooding.^{17,18} Additionally, the IPCC fourth assessment report has reflected that there is little research on floods and human health in China. Therefore, this study aimed to explore the potential association between dysentery and floods based on a longitudinal analysis from 2004 to 2009 in Zhengzhou, Kaifeng and Xinxiang cities. Results will contribute to have a better understanding of the health impacts of floods and assist in developing national strategies to prevent and reduce the risk of infectious diseases with floods.

Materials and methods

Study areas

Fig. 1 shows the geographic position of the three cities in the north center of Henan Province, which are located in the middle reaches of the Yellow River. The similar geographic location determines these cities the characteristics of the warm temperate continental monsoon climate. Kaifeng is located between latitude 34°11'–35°01'N and longitude 113°52'–115°15'E with an annual average temperature from 13.7 to 15.8 °C and an annual average rainfall from 585.3 to 684.1 mm.¹⁹ Zhengzhou, the capital of Henan Province, is located between latitude 34°16'–34°58'N and longitude 112°42'–114°14'E with an annual average temperature from 13.7 to 14.2 °C and an average rainfall per year up and down in 640.9 mm.²⁰ In addition, Xinxiang is located between latitude 34°55'–35°50'N and longitude 113°30'–115°30'E with an annual average temperature from 13.9 to 14.6 °C, and an annual average rainfall per year of 580–640 mm.²¹ The areas of Zhengzhou, Kaifeng and Xinxiang are 7446.2, 6444 and 8629 square kilometers, respectively. In 2009, the population of Zhengzhou was approximately 682 million, followed by 475 million in Kaifeng and 562 million in Xinxiang.

Data collection and management

Disease surveillance data

Monthly disease surveillance data on dysentery from January 2004 to December 2009 were obtained from the National Notifiable Disease Surveillance System (NDSS). The definition of dysentery from the NSDD is a group of the

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