



Association between floods and infectious diarrhea and their effect modifiers in Hunan province, China: A two-stage model

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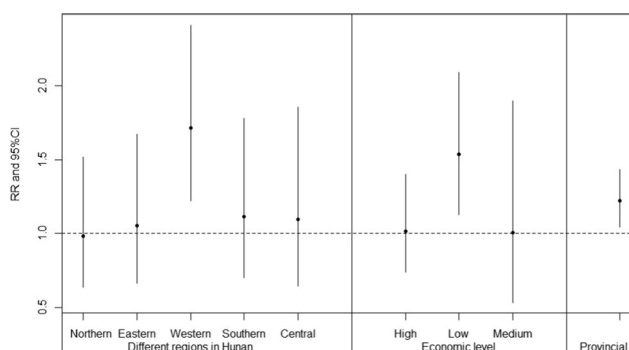
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HIGHLIGHTS

- A total of 134,571 cases of infectious diarrhea were included in our study.
- The cumulative and lagged effect of floods in provincial level was reported.
- Our study identified two potential effect modifiers.

GRAPHICAL ABSTRACT



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ABSTRACT

Background: Understanding the potential links between floods and infectious diarrhea is important under the context of climate change. However, little is known about the risk of infectious diarrhea after floods and what factors could modify these effects in China.

Objectives: This study aims to quantitatively examine the relationship between floods and infectious diarrhea and their effect modifiers.

Methods: Weekly number of infectious diarrhea cases from 2004 to 2011 during flood season in Hunan province were supplied by the National Notifiable Disease Surveillance System. Flood and meteorological data over the same period were obtained. A two-stage model was used to estimate a provincial average association and their effect modifiers between floods and infectious diarrhea, accounting for other confounders.

Results: A total of 134,571 cases of infectious diarrhea were notified from 2004 to 2011. After controlling for seasonality, long-term trends, and meteorological factors, floods were significantly associated with infectious diarrhea in the provincial level with a cumulative RR of 1.22 (95% CI: 1.05, 1.43) with a lagged effect of 0–1 week. Geographic locations and economic levels were identified as effect modifiers, with a higher impact of floods on infectious diarrhea in the western and regions with a low economic level of Hunan.

Conclusions: Our study provides strong evidence of a positive association between floods and infectious diarrhea

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in the study area. Local control strategies for public health should be taken in time to prevent and reduce the risk of infectious diarrhea after floods, especially for the vulnerable regions identified.

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1. Introduction

Diarrheal diseases are one of the leading mortality causes of children worldwide. In 2010, diarrheal diseases caused about 10.5% (0.801 million) of deaths in children under 5 years old all over the world (Liu et al., 2012). According to the National Notifiable Disease Surveillance System (NDSS), there were 1,086,343 new infectious diarrhea cases reported in 2011 in China (DCFP, 2011). Hunan province is one of the most seriously affected provinces along the Yangtze River Region of China with millions of people affected each year.

Floods are the most common natural disaster in both developed and developing countries, contributing to 52.1% of the total occurrence of natural disasters in 2011 (Guha-Sapir et al., 2012). Risks of floods are expected to increase due to frequent and heavy precipitation events in future. For example, some heavily-populated mega-deltas in Asia will be at great risks due to increased flooding from the rivers (Parry, 2007). Hunan, located in the Yangtze River Basin, is one of the flood-prone provinces in China. In average, there has been one to three floods occurred in cities of Hunan province each year due to persistent and heavy rainfall (Song, 2012).

Health effects of floods include death, injuries, communicable diseases, water-borne diseases, vector-borne diseases, non-communicable diseases, psychosocial health, and malnutrition (Alderman et al., 2012). In addition, diarrhea is one of the most important after effects of floods especially in areas where the population do not have the access to clean water and sanitation (Aherm et al., 2005). However, the association between infectious diarrhea and floods is far from clear with inconsistent epidemiologic evidences. A survey after the 2002 floods in Germany identifies contacting with floodwater as a risk factor for diarrhea (Schnitzler et al., 2007). Ding et al. found that floods were associated with infectious diarrhea significantly by a study conducted in Anhui, China (Ding et al., 2013). A study from Chennai, India also indicated that extreme precipitation was associated with GI-related hospital admissions (Bush et al., 2014). However, a study developed in Bangladesh found that after controlling for the confounding of seasonality and pre-flood rate differences, there was no clear evidence of increased diarrheal risk during or after floods (Milojevic et al., 2012). Most of these previous studies examining floods and infectious diarrhea were based on one or two cities with very limited research at a provincial level. Effect at a provincial level and effect

modifiers of floods on infectious diarrhea have not been explored before. Therefore, the aim of this study was to quantitatively examine the relationship between floods and infectious diarrhea and their effect modifiers based on a time series data. Results will provide more evidences to support decision making and to develop local strategies for preventing and reducing the risks of infectious diarrhea after floods.

2. Materials and methods

2.1. Study location and period

The study was conducted in Hunan province which is located between latitudes 24°38' and 30°08'N and longitudes 108°47' and 114°15'E (Fig. 1). It included 14 cities and was divided into southern, northern, eastern, central, and western parts. 13 cities in Hunan province were chosen as our study area except Xiangtan city because there was no weather station for this city. It is characterized by a humid subtropical monsoon climate with an annual mean rainfall between 1200–1700 mm and an annual mean temperature between 15–18 °C. In 2011, Hunan has a population of 71.35 million with an area of 211,829 km², and the per capita GDP of 4342 US dollars. Considering the seasonal distribution of floods and infectious diarrhea, the flood seasons (periods between April and September) from 2004 to 2011 were chosen as our study periods.

2.2. Data collection

Weekly number of infectious diarrhea cases from 2004 to 2011 were supplied by the NDSS. The definition of infectious diarrhea, according to the National Health and Family Planning Commission of the People's Republic of China (NHFPC), is a group of infectious diseases which caused by panel of microbes (including bacteria, viruses, and parasites) and have diarrhea as the typical symptom, including dysentery, cholera, paratyphoid, typhoid, and other infectious diarrhea. In our study, all infectious diarrhea cases were defined based on the diagnostic criteria and principles of management for infectious diarrhea (WS 271-2007) (NHFPC, 2007).

Flood data were supplied by the Yearbooks of Meteorological Disasters in China, which recorded the number of deaths, damaged areas, occurrence time, and economic loss due to floods (Song, 2012). Flooding



Fig. 1. Location of the study area in China.

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