Environment International 106 (2017) 19–26

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

The effect of high temperature on cause-specific mortality: A multi-county analysis in China

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ARTICLE INFO

Keywords:
High temperature
Cause-specific mortality
Multi-counties
Stratified population
DLNM

ABSTRACT

Although existing studies have linked high temperature to mortality in a small number of regions, less evidence is available on the variation in the associations between high temperature exposure and cause-specific mortality of multiple regions in China. Our study focused on the use of time series analysis to quantify the association between high temperature and different cause-specific mortalities for susceptible populations for 43 counties in China. Two-stage analyses adopting a distributed lag non-linear model (DLNM) and a meta-analysis allowed us to obtain county-specific estimates and national-scale pooled estimates of the nonlinear temperature-mortality relationship. We also considered different populations stratified by age and sex, causes of death, absolute and relative temperature patterns, and potential confounding from air pollutants. All of the observed cause-specific mortalities are significantly associated with higher temperature. The estimated effects of high temperature on mortality varied by spatial distribution and temperature patterns. Compared with the 90th percentile temperature, the overall relative risk (RR) at the 99th percentile temperature for non-accidental mortality is 1.105 (95%CI: 1.089, 1.122), for circulatory disease is 1.107 (95%CI: 1.081, 1.133), for respiratory disease is 1.095 (95%CI: 1.050, 1.142), for coronary heart disease is 1.073 (95%CI: 1.047, 1.099), for acute myocardial infarction is 1.072 (95%CI: 1.042, 1.104), and for stroke is 1.095 (95%CI: 1.052, 1.138). Based on our findings, we believe that heat-related health effect in China is a significant issue that requires more attention and allocation of existing resources.

1. Introduction

High ambient temperature is an important risk factor associated with health effects (Basu, 2009; Hajat and Kosatky, 2010). Many earlier studies have reported increased mortality caused by high temperature in various locations and climates within a single country (Barnett, 2007; Chen et al., 2013; Hajat et al., 2006). Recently, several eco-epidemiological studies have even estimated increased high temperature-induced mortality from multiple countries globally (Gasparrini et al., 2015; Guo et al., 2014). Conclusions from these studies indicate the need for multicenter research, as results from a wide range of locations could be used for the comparison and identification of heterogeneity in heat effects. In addition, studies including multiple locations are helpful for capturing spatial differences and support more target-specific policy making.

Unfortunately, most of the previous work in China on this subject have been focused on single cities. Due to the amplified effects of global climate change in recent years, there are growing public health impacts of exposure to high temperature in China (Committee of National Assessment Report on Climate Change, 2015). In recent years, there have been an increased number of multicenter studies in China. For example: the heat effect on stroke in eight Chinese cities (Chen et al., 2013), the health effect from high temperature on non-accidental mortality in seven Chinese cities (Zeng et al., 2016) and 17 large cities (Ma et al., 2014), and the investigation of heat effects in 66 communities (Huang et al., 2015). However, all of these studies focused on only a single outcome or a couple of main outcomes (cardiovascular and respiratory diseases) and mostly adopted a pre-specified temperature or temperature pattern such as extremely high or moderately high temperatures. Since high temperatures could cause a wide range of diseases through multiple biological pathways (Gasparrini et al., 2012), and different temperature patterns may present different regional estimates (Anderson and Bell, 2009; Medinaramón and Schwartz, 2007), many questions still remain to be explored. There is currently

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http://dx.doi.org/10.1016/j.envint.2017.05.019
Received 8 February 2017; Received in revised form 22 May 2017; Accepted 22 May 2017
Available online 27 May 2017

not enough evidence to characterize the cause-specific temperature-mortality relationship under different temperature patterns in multi-locations across China, a country with a wide range of climates, high mortality rates for sensitive diseases, and a highly diverse population. A better understanding of the relationship between high temperature and mortality of different causes and vulnerable subpopulations is not only critical to health risk evaluation in future research work but also to policy makers who plan suitable prevention and intervention strategies under a changing climate (Anderson and Bell, 2009).

This study analyzes cause-specific mortalities in 43 Chinese counties, controlling for different temperature patterns and using subpopulations stratified by age and sex. County-specific and national effects are estimated using advanced statistical modeling. We aim to examine how heat effects estimated for non-accidental and five specific causes of mortality vary across diverse climates in different parts of China.

2. Methods

2.1. Data collection

The study includes 43 counties from 12 cities (city is larger than county in China) distributed from northern to southern China (Fig. 1): Harbin (four counties), Beijing (seven counties), Shijiazhuang (four counties), Taiyuan (two counties), Xi'an (two counties), Nanjing (three counties), Suzhou (one county), Shanghai (seven counties), Chengdu (six counties), Wuhan (three counties), Guangzhou (three counties), and Shenzhen (one county). Of these cities, counties of Harbin are located in a mid-temperate zone; counties from Beijing, Shijiazhuang, Taiyuan, and Xi'an are located in a warm-temperate zone; all other counties are located in a subtropical zone. Daily data from 2013 to 2015 on mortality, weather conditions, and air pollution were obtained for each county (see Table A1 for county-specific information).

Daily mortality data in each county were obtained from the national Death Surveillance Point System (DSPs). The International Classification of Diseases, 10th revision (ICD-10) code was adopted to classify non-accidental mortality (A00-R99) and cause-specific mortality for each county, including circulatory disease (Cir., I00-I99), respiratory disease (Resp., J00-J99), coronary heart disease (CHD, I20-I25), acute myocardial infarction (AMI, I21-I22), and stroke (I60-I64). Mortality counts of different causes were also stratified by sex and age (0–65 years, 65–74 years, over 74 years).

Weather data were obtained from the Chinese meteorological data sharing website and include daily mean temperature, maximum temperature, minimum temperature, and relative humidity in each county. We adopted daily mean temperature to evaluate the effects on mortality. We also examined the potential confounding effect from ambient air pollution on mortality by simultaneously considering daily county-specific concentrations of O_3 and $PM_{2.5}$ obtained from the National Air Pollution Monitoring System.

2.2. Data analysis

The temperature-mortality associations were investigated with a two-stage analysis using time series data from the 43 counties. The first-stage analysis at the county-level employed a quasi-Poisson regression model to estimate county-specific relative risks (RRs) for temperature-

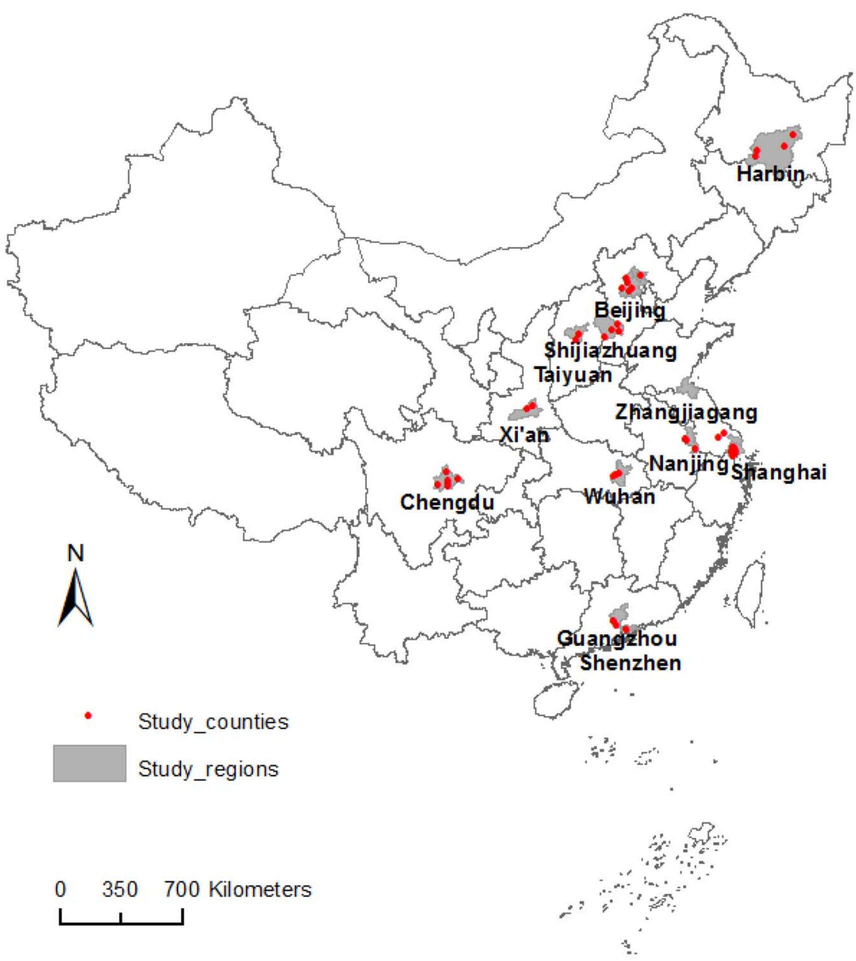

Fig. 1. Geographical distribution of the studied counties.