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Temperature and mortality on the roof of the world: A time-series analysis in three Tibetan counties, China

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HIGHLIGHTS

- Due to the rapid warming and unique high-altitude ecosystem, Tibet is considered to be highly vulnerable to global warming.
- The effect of cold was stronger and lasted longer than the heat effect.
- Vulnerable subpopulations include males, the elderly and illiterate people.
- The effect of heat was more marked for cardiovascular deaths than total non-accidental deaths.

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ABSTRACT

Background: Tibet, with an average altitude of more than 4,000 meters, is warming faster than anywhere else in China. However, there have been no studies in Tibet of the relation between ambient temperature and mortality.
Methods: We examined mean temperature and daily mortality in three Tibetan counties (Chengguan, Jiangzi and Naidong) using a distributed lag non-linear model (DLNM) based on 5,610 deaths that occurred in 2008–2012. We separately investigated hot and cold effects on non-accidental deaths, cardiovascular deaths, out-of-hospital deaths and vulnerability factors including age, sex and education.
Results: In all three counties, the effect of heat tended to be immediate, while the impact of cold lasted longer. The effects were consistent but modest in size and not statistically significant except for cumulative cold effects in Jiangzi (lag = 0–14, RR = 2.251, 95% CI = 1.054–4.849). Those who were more vulnerable to temperature extremes tended to be men, the elderly (over 65 years) and illiterate persons. We found stronger temperature effects on cardiovascular deaths than on all-cause mortality, and we also observed an increase in out-of-hospital mortality in one county.
Conclusions: This is the first study to investigate the temperature–mortality relationship in Tibet, and the findings may guide public health programs and other interventions to protect the population against extreme temperatures in a developing Tibet.

1. Introduction

The adverse impacts of both hot and cold temperatures on daily mortality have been reported worldwide (Basu and Ostro, 2008; Chung et al., 2009; Guo et al., 2012; McMichael et al., 2008). Susceptibility to temperature extremes tends to vary by cause of death, place where the death occurs, demographic and socioeconomic circumstances (Díaz et al., 2002; Martiello and Giacchi, 2010; O'Neill et al., 2003; Schwartz, 2005). Cardiovascular diseases are the number one cause of death globally and also in China. Evidence is mounting weather changes (e.g., variations in temperature) influence cardiovascular mortality and morbidity (Atsumi et al., 2013; Khanjani and Bahrampour, 2013; Madrigano et al., 2013; Wichmann et al., 2013; Zeng et al., 2012). Some studies found that those dying outside a hospital were more vulnerable to extreme cold (O'Neill et al., 2003) and heat (Medina-Ramón

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et al., 2006) than individuals who died in-hospital. It is clearly important to identify those who are most seriously affected by variations in temperature in order to efficiently target interventions and develop location-specific public health programs.

To date, most studies in the field have been conducted in developed countries, and there is less information about health effects of temperatures available from developing countries though these are considered to be most vulnerable to climate change and climate variability. Tibet of China lies at an average altitude of more than 4000 meters. This region accounts for one eighth of China's total land mass and is often called "the third pole of the world" due to extensive glaciation and the enormous volume of water held in ice sheets and snowfields. Tibet has experienced noticeable changes in climate over the past 50 years (Du et al., 2011; Liu and Chen, 2000). The temperatures in Tibet have been rising by 0.16 °C for the annual mean and 0.32 °C for the winter mean every decade since the 1960s. The rates of warming are higher than those for the Northern Hemisphere and the same latitudinal zone in the same period (Liu and Chen, 2000). A recent study claimed that winter temperatures in Tibet have been increasing at a faster rate than any other inland area of China, between 0.29 °C 1.04 °C every decade, although Tibetans still experience periods of extreme cold (Du et al., 2011). Tibetans normally rely on subsistence farming, most commonly raising yaks, and the viability of this industry is threatened by extreme weather and climate change. These peculiarities of Tibet indicate that it is important to explore effects of temperature on health in this setting and, where possible, to identify vulnerable subgroups.

The aim of this study was therefore to examine the relationship between temperature and all-cause mortality (excluding accidental deaths) in three counties in Tibet. We also aimed to identify factors that increase susceptibility to hot and cold effects. Separately, we investigated the influence of temperatures on cardiovascular deaths and deaths occurring out-of-hospital.

2. Methods

2.1. Study population and data collection

We conducted a time-series analysis using temperature and mortality data from three Tibetan counties (Chengguan, Lhasa; Jiangzi, Rikaze; and Naidong, Shannan) during the period 2008–2012 (Fig. 1). Chengguan is the urban district of Lhasa (the capital city of Tibet), while Naidong and Jiangzi are predominantly rural. These are three of the five counties that have been randomly selected by the Chinese Center for Disease Control and Prevention to carry out death surveillance in Tibet since 2008. We excluded data from the other two counties because of small numbers of deaths. The study was approved by the Ethical Review Committee of Chinese Center for Disease Control and Prevention (No. 201214).

We obtained daily mortality data for each county during 2008–2012 from the Tibetan Center for Disease Control and Prevention. Death certificates include date, place and cause of death and personal characteristics such as age, sex, occupation, ethnic group and educational attainment. Based on the *International Classification of Disease, 10th Revision, Clinical Modification* (ICD-10), we classified the data into non-accidental deaths (A00-R99) and cardiovascular deaths (I00-99). Meteorological data on daily temperature and humidity are provided by the National Climate Center. There are no data from Naidong, so we used temperature records from the nearest county with similar latitude and altitude.

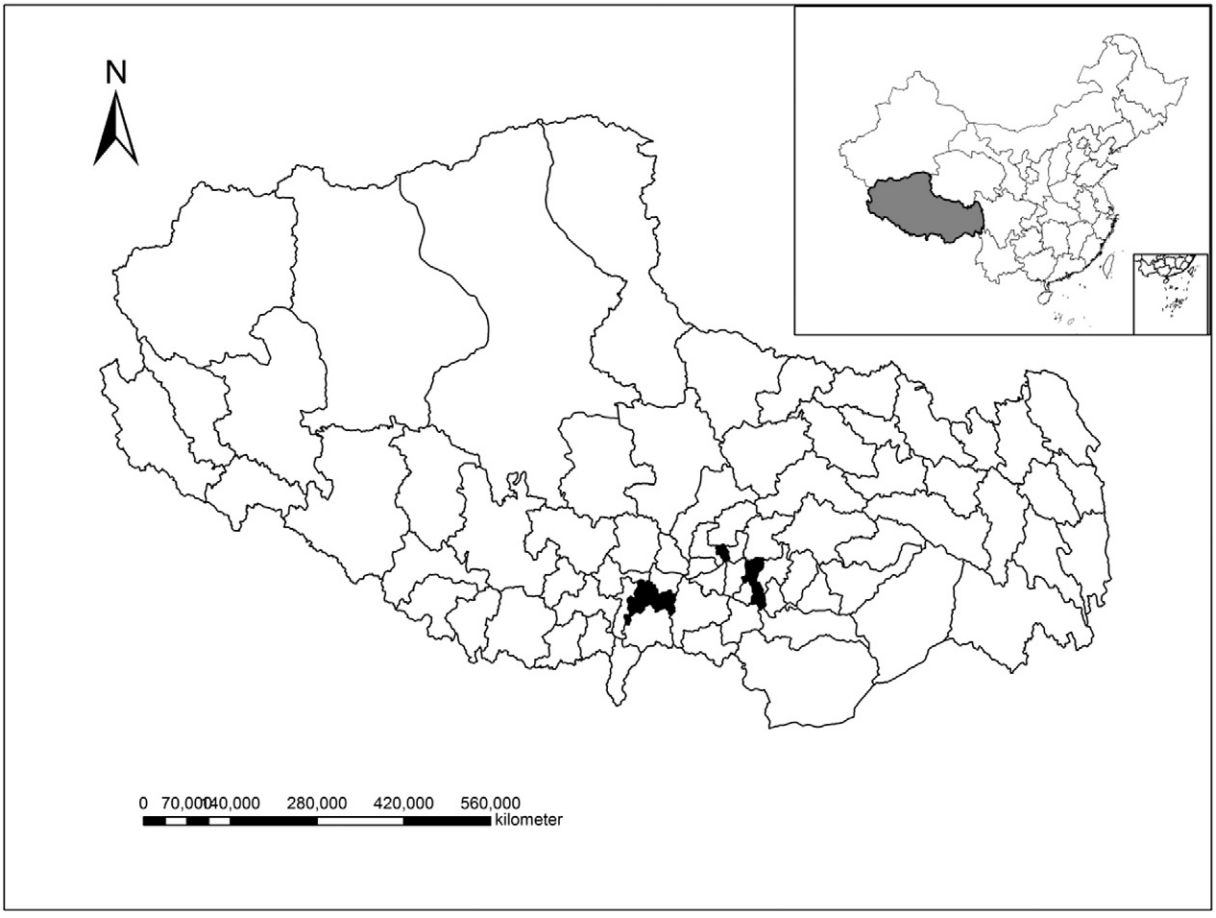

Fig. 1. The three counties (in black) into this research.