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Comprehensive approach to understand the association between diurnal temperature range and mortality in East Asia

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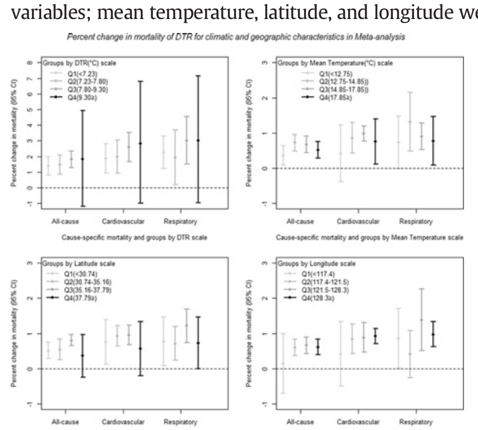
HIGHLIGHTS

- We examined DTR effects on cause- and age-specific mortality in East Asia areas.
- We explored geographic and climatic determinants in the extent of DTR effects.
- We found greater DTR effects in respiratory mortality and in the elderly.
- DTR effects varied by geographic characteristic; longitude, and scale of DTR.

GRAPHICAL ABSTRACT

For the following graphical abstract using quartile cutoff values for climatic (DTR, and mean temperature) and geographic (latitude, and longitude) characteristics, we divided the 30 cities into 4 different groups and conducted a meta-analysis within the groups using either a random or fixed effects model. We applied 1 standard deviation (SD) of DTR according to cities and referring DTR effect by 1 SD increase for the groups of DTR scale and other variables; mean temperature, latitude, and longitude were applied 1 °C increase of DTR.



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ABSTRACT

An adverse association between diurnal temperature range (DTR) and mortality has been suggested, but with variable relationships in different cities. Comprehensive approaches to understanding the health effects of DTR using multinational data are required. We investigated the association between DTR and cause-specific mortality in an age-specific population and assessed the dependency of the health effects of DTR on geographic and climatic factors. Poisson generalized linear regression analyses with allowances for over-dispersion were applied to daily DTR and cause-specific mortality data from 30 cities in China, Japan, Korea, and Taiwan between 1979 and 2010, adjusted for various climatic and environmental factors. City-specific effects of DTR were estimated and summarized for the overall effects using geographic and climatic determinants in a meta-analysis. For all-cause,

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circulatory, and respiratory mortality, the greatest city-specific effects per 1 °C DTR were found in Tianjin, China (1.80%; 95% confidence interval [CI]: 0.48, 3.14); Tangshan, China (2.25%; 95% CI: 0.65, 3.87); and Incheon, Korea (2.84%; 95% CI: 0.04, 5.73), respectively, and overall effects across 30 cities were 0.58% (95% CI: 0.44, 0.72), 0.81% (95% CI: 0.60, 1.03), and 0.90% (95% CI: 0.63, 1.18), respectively. Using quartile cutoff values for climatic (DTR, and mean temperature) and geographic (latitude, and longitude) characteristics, we divided the 30 cities into 4 different groups and conducted a meta-analysis within the groups using either a random or fixed effects model. Adverse effects of DTR were more pronounced for those aged ≥65 years and varied according to geographic, longitudinal (0.07%; 95% CI: 0.05, 0.10), and climatic characteristics and the scale of DTR (0.33%; 95% CI: 0.12, 0.55) for overall all-cause mortality. The DTR is a risk factor affecting human health, depending on geographic location and the temperature variation, with particular vulnerability in aged populations.

1. Introduction

Extremely low and high temperatures are mortality risk factors (Baccini et al., 2008; Curriero et al., 2002; McMichael et al., 2008), and previous studies suggested that susceptible populations such as infants and the elderly are greatly affected by temperature changes (Basu et al., 2005, 2008; Gouveia et al., 2003; Haines et al., 2006a, 2006b). Although mean temperatures have increased due to climate change, dynamic changes with high variability in temperatures are frequently observed, which also poses a mortality risk (Bobb et al., 2014; Tobias et al., 2014).

Diurnal temperature range (DTR), defined as the difference between daily maximum and daily minimum temperature, is one index of temperature variability to estimate effects on human health, including mortality and morbidity. DTR represents a stable measure of temperature, but because minimum temperature has increased more rapidly than maximum temperature, a widespread decrease in DTR was evident in almost all parts of the globe from 1950 to 1980 (Easterling et al., 1997; Vose et al., 2005). Although DTR is decreasing, the importance of the association between DTR and health is increasing because many are still exposed to DTR and their health is affected by the existing DTR (Lim et al., 2012b; Lim et al., 2013; Xu et al., 2013a, 2013b). Several studies suggested that DTR is associated with mortality (Luo et al., 2013; Yang et al., 2012), cardiovascular and respiratory disease (Ge et al., 2013; Lim et al., 2013; Wang et al., 2013; Xu et al., 2013a), and even infectious diseases (Hii et al., 2011; Xu et al., 2013b).

The association between DTR and cause-specific mortality has been studied in single or multiple cities within one nation, but no comprehensive study has been conducted incorporating the East Asian nations China, Japan, Korea, and Taiwan. Thus, we aimed to investigate the association between DTR and cause-specific (nonaccidental, cardiovascular, and respiratory) mortality within age-specified populations and assess climatic and regional determinants that may explain variation in city-specific associations.

2. Materials and methods

2.1. Study area and population

Data from between 1979 and 2010 were obtained from 30 different cities in East Asia: 6 cities in Korea (Seoul, Incheon, Daejeon, Daegu, Gwangju, and Busan), 15 cities in China (Anshan, Fuzhou, Guangzhou, Hangzhou, Hong Kong, Lanzhou, Shanghai, Shenyang, Suzhou, Taiyuan, Tangshan, Tianjin, Wuhan, Wulumuqi, and Xi'an), 6 cities in Japan (Sapporo, Sendai, Tokyo, Nagoya, Osaka, and Kitakyushu), and 3 cities in Taiwan (Taipei, Taichung, and Kaohsiung).

We obtained mortality data from the Korea National Statistical Office, the Center for Disease Prevention and Control (China), the Ministry of Health and Welfare of Japan, and the National Death Registry of Taiwan. The study period varied by city, being longest for Tokyo and Nagoya in Japan (30 years, 1979–2009) and shorter in cities in China (2001–2004 for Shanghai and 2007–2008 for Guangzhou).

To estimate the effect of DTR on cause-specific mortality, we used the International Classification of Disease 10th Revision (ICD-10) diagnoses for death defined as all-cause (ICD-10; A00-R99, excluding deaths from external causes), circulatory disease (ICD-10; I00-I99), and respiratory disease (ICD-10; J00-J99) mortality. We analyzed 2 different age groups: ≥65 and <65 years of age. Limitations of mortality data meant we were unable to estimate age-specific effects in some cities for nonaccidental mortality (Anshan, Hangzhou, Tangshan, and Wulumuqi in China) and cause-specific mortality (all 15 cities in China). This study was approved by the Institutional Review Board of Seoul National University, School of Public Health (65–2013–12–05).

2.2. Environmental variables

Meteorological data including daily mean temperature, maximum temperature, minimum temperature, relative humidity, and air pressure were obtained from the Korean Meteorological Administration, the China Meteorological Data Sharing Service System, the Japan Meteorological Agency, and the Taiwan Environmental Protection Administration. DTR was calculated as the difference between daily minimum and maximum temperatures. Because air pressure data were not available for China, we excluded air pressure in the model only for China.

Daily concentrations for particulate matter ≤10 μm in aerodynamic diameter (PM_{10}), sulfur dioxide (SO_2) (parts per billion [ppb]) and nitrogen dioxide (NO_2) (ppb) were collected from the National Institute of Environmental Research, Korea; the Environmental Monitoring Center, China; the National Institute for Environmental Studies, Japan; and the Taiwan Environmental Protection Administration.

2.3. Statistical analysis

We used Poisson generalized linear regression models with allowances for over-dispersion to quantify city-specific effects of DTR on cause-specific mortality. All environmental variables (mean values for PM_{10}, NO_2, SO_2, temperature, relative humidity, and air pressure at moving-average lags 0–4 for all) and day of week were controlled for in the model. Mean temperature was controlled for with natural cubic splines with 7 degrees of freedom (*df*) and long-term trends with 7 *df* per year. We also considered the lag effects of weather conditions and pollutant concentrations because environmental conditions on the current day and several preceding days affect mortality incidence on any given day (Braga et al., 2001). We used distributed lag linear and nonlinear models (DLNM) to detect the lags of DTR and modeled the marginal relationship between all-cause mortality and DTR over the average of the current day (lag 0) and the preceding 4 days (lags 1–4) in linear terms. The moving-average lag structure (lags 0–4) is the 5-day moving average of the current and previous 4 days' values. We stratified the population according to age (<65 and ≥65 years old) to identify susceptible populations, and all results are expressed as percent increases in cause-specific mortality per 1 °C increase in DTR.