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Temperature effects on hospital admissions for kidney morbidity in Taiwan

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HIGHLIGHTS

- V or J-shaped association was observed between daily temperatures and hospital admissions for renal diseases in Taiwan.
- The pooled relative risks accounting for 8 days of lag for the 7 study areas were 1.1 at 18 °C and 1.46 at 30 °C.
- There is no difference of the relative risk estimates for hospital admissions between younger and elderly population.
- We found significant protective effects of hospital admissions for prolonged cold extremes, but not for heat extremes.

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ABSTRACT

Objective: This study aimed to associate hospital admissions of kidney diseases with extreme temperature and prolonged heat/cold events in 7 regions of Taiwan.
Methods: Age-specific (<65 years, 65+years and all ages) hospital admission records of nephritis, nephrotic syndrome, or nephrosis, in the form of electronic insurance reimbursement claims, were retrieved from Taiwan's National Health Insurance Research Database during the period of 2000–2008. The area–age-specific relative risk (RR) accounting for 8 days of lag for temperature on hospital admissions of kidney diseases were estimated using distributed lag non-linear models with the Poisson distribution controlling for extreme temperature events, levels of air pollutants (PM_{10}, O_3, and NO_2) and potential confounders.
Results: We observed a V or J-shape association between daily average temperatures and the RR estimates for hospital admissions of kidney diseases in Taiwan. The lowest risk for hospital admissions of kidney diseases was found at around 25 °C, and risk increased as temperatures deviated from 25 °C. The pooled cumulative 8-day RR for all ages of population of the 7 study areas were 1.10 (95% confidence interval (CI): 1.01, 1.19) at 18 °C and 1.45 (95% CI: 1.27, 1.64) at 30 °C. High temperature has more profound influence on hospital admission of kidney diseases than low temperature. Temperature risks for hospital admissions were similar between younger (<65 years) and elderly (65+years) population. This study observed no significant effects of prolonged heat extremes on hospital admissions of kidney diseases.
Conclusions: The heat effect for kidney morbidities leading to hospital admission was more significant than that of the cold temperature. This study did not find the age-dependent relative risks for temperature associating with hospital admissions of kidney diseases.

1. Introduction

Climate changes in recent years are being characterized by the increasing frequency and intensity of extreme temperatures (Meehl and Tebaldi, 2004). Most temperature related mortality and morbidity studies are primarily focused on cardiovascular or respiratory diseases in which the associations between the extreme high temperature and mortality are often depicted, either a U-, V-, or J-shaped curve in many regions (Curriero et al., 2002; Gouveia et al., 2003; Lin et al., 2011; McMichael et al., 2008). However, the association of temperature changes with other diseases, such as kidney morbidity has not yet been investigated extensively. It has been documented that exposure

Abbreviations: ARF, acute renal failure; CI, confidence interval; CWB, Central Weather Bureau; DLNM, distributed lag non-linear model; ERV, emergency room visits; NHIRD, National Health Insurance Research Database; PM_{10}, particulate matter less than 10 μm in aerodynamic diameter; RR, relative risk; RH, relative humidity; TEPA, Taiwan Environmental Protection Administration; WS, wind speed.

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to high temperature could add additional stress to kidneys leading to the thermoregulatory, physiological, and circulatory adjustments necessary to cope with extreme heat (Kovats and Hajat, 2008). It has been shown that individuals who are at risks of developing renal dysfunctions, such as elders, also have elevated risks of developing hyperthermia, dehydration, disorder of fluid and electrolyte imbalance, acute renal failure (ARF), heat stroke and heat exhaustion during heat wave (Flynn et al., 2005; Kovats and Hajat, 2008; Semenza, 1999; Tan et al., 1995; Varghese et al., 2005).

Although the effects of extreme temperatures on various diseases depended on demographic, socio-economics, prevalent disease, susceptible groups, weather characteristics, and physical and population adaptation factors, the identification of diseases (or symptomatic of diseases) was limited on duration of the reported heat wave, and therefore lacking appropriate temperature exposure–response relationship (Green et al., 2010; Hansen et al., 2008; Josseran et al., 2009; Khalaj et al., 2010; Knowlton et al., 2009; Kovats and Hajat, 2008; Kovats et al., 2004; Nitschke et al., 2007, 2011; Semenza et al., 1999; Wang et al., 2012a). For instance, Chicago heat wave in 1995 reported major hospitalization treatment for dehydration, heat stroke and heat exhaustion (Semenza et al., 1999). California heat wave in 2006 reported significant increases of hospitalization for ARF, electrolyte imbalance and nephritis, as compared with non-heat wave period (Knowlton et al., 2009). Studies in Australia and France showed significant increase of emergency room visits (ERV) in the elderly population, and pointed out the influence for intense on prolong effect on renal morbidity (Josseran et al., 2009; Nitschke et al.; Wang et al., 2012a). Despite of the suggested association of increasing kidney morbidity and mortality during the reported heat wave events, there are very few studies on the effects of extreme low temperatures. The U.S. Centers for Disease Control and Prevention (CDC) has reported that hundreds of hypothermia cases due to the exposure to cold temperature that eventually developed renal failure and died (CDC, 2004, 2006). Studies also found that low temperature exposure have caused kidney damage in diabetic patients and in experimental animals (Sabharwal et al., 2004; Yamada et al., 2010).

Taiwan, the Republic of China, comprises approximately twenty-three million residents, and is located in the subtropical area in the western part of the Pacific Ocean, with daily average temperature at 24 °C (ranging from 8 to 33 °C in the urban areas) and 80% relative humidity. Although burden of common diseases in Taiwan is similar to other western countries, the end-stage renal disease incidence and prevalence in Taiwan ranked first and second in the world (Department of Health, 2008; Yang and Hwang, 2008). While kidney and renal-related illness are common in Taiwan, mortality caused by renal disease is ranked #10 in 2008. Therefore, patients already with kidney impairments might be more sensitive to the fluctuation of temperature and consequently have higher risks for hospital admissions due to kidney related morbidity than others (Kovats and Hajat, 2008).

Our previous studies have indicated that not only mortality but also the ERV is associated with temperature and prolonged temperature extremes for population in Taiwan (Lin et al., 2011; Wang et al., 2012b). Temperature effect on hospital admissions of kidney diseases based on its high prevalence in Taiwan is, therefore, worthwhile evaluating. This study extends previous research that aimed to investigate the relative risk (RR) of hospital admissions for kidney diseases associated with non-linear and delayed temperature effect (8 days of lag). Furthermore, additional effects from prolonged extreme temperature events, or the annual first extreme temperature event stratifying by ages (overall population, <65 years, and 65 + years) in Taiwan are investigated.

2. Materials and methods

2.1. Study areas and data sources

Taiwan is situated within the subtropical zone with 150 km wide and 350 km long, stretching from 22 to 25° north latitude. There are 22 cities/counties in the main island in which approximately 99.6% of total population in Taiwan resided. We divided these 22 administrative regions into 7 study areas (Taipei, TaoHsinMiao, KeeYi, Central Taiwan, YunChiaNan, East Taiwan and Southern Taiwan) based on geographical, social and economical characteristics for further area-specific analysis (Fig. 1). We used daily meteorological records from Taiwan's Central Weather Bureau (CWB), universal health insurance claims obtained from the National Health Insurance Research Database (NHIRD), and daily air pollution monitoring records from Taiwan Environmental Protection Administration (TEPA) in this study. Those data span from 2000 to 2008.

The CWB data included 24-hour average temperature, maximum temperature, minimum temperature, relative humidity, wind speed and barometric pressure from 25 real-time monitoring stations in Taiwan (Taiwan Central Weather Bureau, 2011a). The present study used daily average weather measurements from 3, 2, 2, 2, 4, 4 and 3 weather stations that are most representative to population exposure in Taipei, TaoHsinMiao, KeeYi, Central Taiwan, YunChiaNan, East Taiwan and Southern Taiwan, respectively (Taiwan Central Weather Bureau, 2011b) (Fig. 1). The Taiwan National Health Insurance program covers over 22 millions of citizens, or 96% of the total population in Taiwan (Bureau of National Health Insurance, 2001) since its inception in 1996. The NHIRD, created by Taiwan National Health Research Institute consists of a national representative population of one million people randomly sampled from all insured residents with their electronic reimbursement claim records since 2000 (Taiwan National Health Insurance Research Database, 2011). NHIRD contains scrambled identification numbers of citizens and information on gender, birth dates, health care received, outpatient visits, inpatient admissions and discharges, and medical care providers. NHIRD is intended for research uses, and it is almost not possible to query the data alone to identify individuals at any level using this database. Disease diagnoses were coded according to the 9th

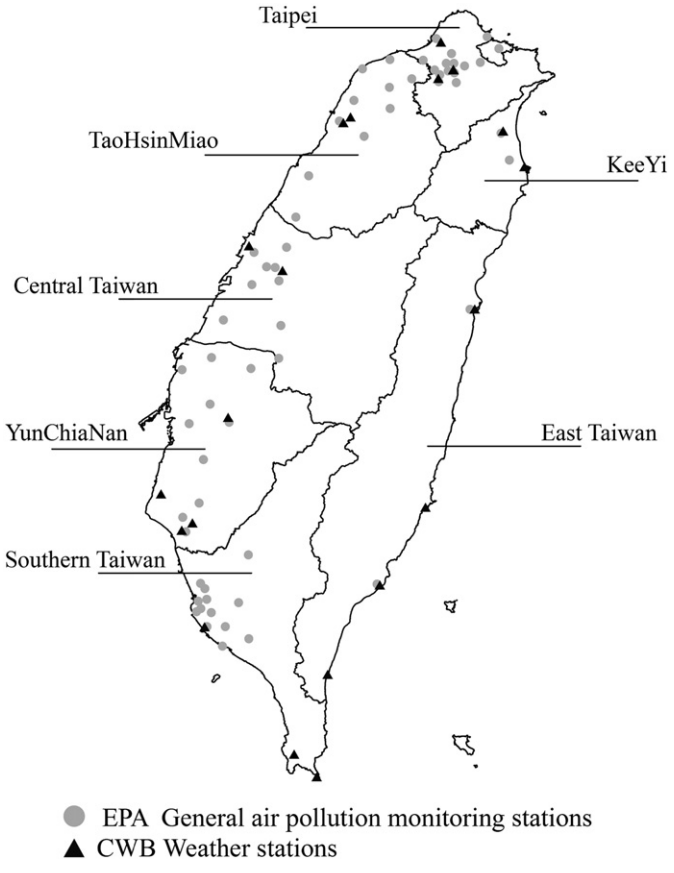

Fig. 1. Study areas and locations of general air monitoring and weather stations in Taiwan, 2000–2008.