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Mental disease-related emergency admissions attributable to hot temperatures

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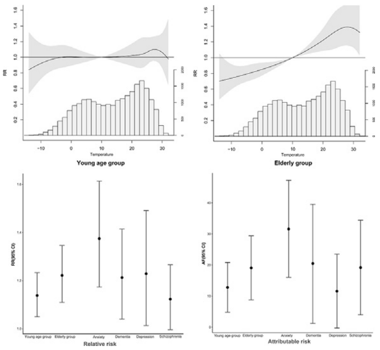
HIGHLIGHTS

- We quantified the burden of mental disease due to hot temperatures.
- Elderly were more susceptible than young group to hot temperatures.
- The risks for specific mental diseases attributed to hot temperatures were also high.
- 14.6% of EA for mental disease can be attributed to extreme hot temperatures.

GRAPHICAL ABSTRACT



This graphical abstract indicates the overall cumulative relative risk and attributable fractions attributed to extreme hot temperature by subgroup.

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ABSTRACT

Objective: The association between high temperature and mental disease has been the focus of several studies worldwide. However, no studies have focused on the mental disease burden attributable to hot temperature. Here, we aim to quantify the risk attributed to hot temperatures based on the exposure-lag-response relationship between temperature and mental diseases.

Method: From data on daily temperature and emergency admissions (EA) for mental diseases collected from 6 major cities (Seoul, Incheon, Daejeon, Daegu, Busan, and Gwangju in South Korea) over a period of 11 years (2003–2013), we estimated temperature-disease associations using a distributed lag non-linear model, and we pooled the data by city through multivariate meta-analysis. Cumulative relative risk and attributable risks were calculated for extreme hot temperatures, defined as the 99th percentile relative to the 50th percentile of temperatures.

Results: The strongest association between mental disease and high temperature was seen within a period of 0–4 days of high temperature exposure. Our results reveal that 14.6% of EA for mental disease were due to extreme hot temperatures, and the elderly were more susceptible (19.1%). Specific mental diseases, including anxiety, dementia, schizophrenia, and depression, also showed significant risk attributed to hot temperatures. Of all EA for anxiety, 31.6% were attributed to extremely hot temperatures.

Conclusions: High temperature was responsible for an attributable risk for mental disease, and the burden was

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Abbreviations: AF, attributable fraction; AN, attributable number; CI, confidence intervals; DLNM, distributed lag non-linear model; EA, emergency admissions; RR, relative risk.

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higher in the elderly. This finding has important implications for designing appropriate public health policies to minimize the impact of high temperature on mental health.

1. Introduction

The burden of mental disorders continues to grow with significant impacts on health and with major social, human rights, and economic consequences in all countries (World Health Organization, 2013). Three types of mental illness appeared in the top 20 causes of global burden of disease in 2013: major depression (2nd), anxiety disorders (7th), and schizophrenia (11th) (Global Burden of Disease Study 2013 Collaborators, 2015). To reduce the burden of mental disease, many risk factors that have established effects on the incidence of mental disease, such as individual attributes, social circumstances, and environmental factors (World Health Organization, 2012), need to be studied.

It has been proposed that high temperatures are associated with the symptoms of mental disease. Recently, several studies in a few countries have assessed the relationship between hot temperatures and hospital admissions for mental disease. Wang et al. found a 29% increase in the number of mental and behavioral disease-related emergency room visits over 7 days, after exposure to high temperatures in Toronto, Canada (Wang et al., 2014). In Vietnam, Trang et al. reported an increase in hospital admissions for mental disorders during heatwaves when compared with non-heatwave periods (Trang et al., 2016). Most recently, patients with mental disease in Shanghai were shown to have a relative risk (RR) of 1.266 in extreme hot temperatures, compared with median temperature (Trang et al., 2016).

Attributable fraction (AF) and attributable number (AN) are calculated based on the estimated RR and represent the fraction and number, respectively, of cases or deaths from a disease that would be prevented in the absence of exposure to a specific risk factor (Steenland and Armstrong, 2006). Recently, numerous studies have estimated AF based on distributed lag non-linear model (DLNM) analysis in a wide range of cardiovascular, respiratory, and other diseases (Onozuka and Hagihara, 2015; Qiu et al., 2016). Determining AF for environmental risk factors has important policy implications and is essential for planning public health interventions and strategies (Gasparrini and Leone, 2014; Gasparrini et al., 2015). So far, studies have estimated the association of mental disease and high temperature in a single city in terms of RR, providing estimates for the exposure-response relationship without clear and direct consideration of the impact of high temperature. To our knowledge, no studies have quantified attributable burden in terms of relative excess in mortality or morbidity for mental diseases, which can be shown as AF or AN.

Here, we aimed to analyze the associations between mental disease and hot temperatures by looking at their complex exposure-lag-response relationship through multivariate meta-regression models and DLNM. We also provided information on the attributable burden of mental disease, by age group and by specific disease, due to extreme hot temperatures from a national database in Korea.

2. Material and methods

2.1. Study area

Korea comprises 9 provinces and 7 metropolitan cities with different community characteristics. Provinces are composed of small cities and rural areas, and metropolitan cities are homogeneous urban areas that have a population of >1 million. To represent South Korea, we conducted our study in 6 metropolitan cities (Seoul, Incheon, Daejeon, Daegu, Busan, and Gwangju), which share the added advantages of having many hospitals and similar characteristics.

2.2. Data collection

Korea operates a mandatory universal health insurance system, with a centralized healthcare claims database that provides a unique nationwide source of information on healthcare resource utilization (Kang et al., 2012). We obtained daily EA data from the Korean National Health Insurance Corporation in the period of 2003 to 2013. The Korean National Health Insurance claims database, which contains medical information for almost 100% of the Korean population, provided anonymous records of diagnoses in mental disease-related EA without additional information, such as name, address, and disease history. We classified and grouped mental diseases according to the ICD 10 diagnosis codes for mental and behavioral disorders (F00 to F99) and for other specific mental diseases: anxiety (panic disorder with or without agoraphobia, agoraphobia, social phobia, or generalized anxiety disorder) (ICD 10: F40, F41), schizophrenia (ICD 10: F20, F21), depression (major depressive disorder or dysthymic disorder) (ICD 10: F32, F33), and dementia (ICD 10: F00-F03, G30, G31). Climate data were obtained from the Korean Meteorological Administration and included daily mean temperatures (°C), humidity (%), and total solar radiation (MJ/m^2) for the study time period. For sensitivity analysis, air pollution data, including ambient 24-hour average concentrations, were provided by the National Institute of Environmental Research in Korea.

2.3. Statistical methods

2.3.1. First stage analysis

In the first stage of our analysis, we examined the associations between mental disease-related EA and high temperatures using DLNM with a time-series quasi-Poisson distribution. DLNM has the advantage of estimating the cumulative effects of temperature over multiple days while adjusting for the collinearity of temperature on neighboring days (Gasparrini, 2011). As noted several studies of mental disease, we extended the lag period of 7 days (Peng et al., 2017; Tong et al., 2016). Specifically, we modeled the exposure-response curve using quadratic B-spline with 3 internal knots placed at the 10th, 75th, and 90th percentiles of location-specific temperature distributions, as previously described (Gasparrini et al., 2015). In this approach, the exposure-lag-response curve revealed that the effect of temperature is linear in the dimension of the predictor, therefore we applied a regression model with a distributed lag linear function for temperature and other climate variables, as follows (Gasparrini, 2011):

$$\log(E(Y_t)) = \alpha + NS(Time, 11^{*}8) + NS(Hum_t, 3) + NS(Solar_t, 3) + DOW_t + Temp_{t,l}$$

where $E(Y_t)$ is the observed daily count of emergency admissions for mental diseases; NS is a natural cubic spline; 8 degrees of freedom (df) were used per year to control for long-term trends and seasonality; 3 df were used for relative humidity and daily total solar radiation to control for their potential confounding effects; DOW_t is the day of the week; and $Temp_{t,l}$ is a two-dimensional linear covariate for temperature and lag days with a maximum lag of l.

Controlling for all covariates above in the distributed lag linear model, we calculated the RR and 95% confidence intervals (CI) of the EA per a 1 °C increase in the mean temperature for a cumulative lag effect of 0–4 days, which showed the greatest RR. Additional information is provided in S Table 2 of the Data Supplement.

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