Environmental Pollution xxx (2016) 1–5

Contents lists available at ScienceDirect

Environmental Pollution

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

Hourly associations between heat and ambulance calls☆

Yuming Guo*

Division of Epidemiology and Biostatistics, School of Public Health, University of Queensland, Brisbane, Australia

ARTICLE INFO

Article history:
Received 10 September 2016
Received in revised form
27 October 2016
Accepted 27 October 2016
Available online xxx

Keywords:
Hourly heat effect
Ambulance calls
Case-crossover design

ABSTRACT

Background: The response speed of ambulance calls is very crucial to rescue patients suffering immediately life threatening conditions. The serious health outcomes might be caused by exposing to extreme heat only several hours before. However, limited evidence is available on this topic. This study aims to examine the hourly association between heat and ambulance calls, to improve the ambulance services and to better protect health.
Methods: Hourly data on ambulance calls for non-accidental causes, temperature and air pollutants (PM_{10}, NO_2, and O_3) were collected from Brisbane, Australia, during 2001 and 2007. A time-stratified case-crossover design was used to examine the associations between hourly ambulance calls and temperature during warm season (Nov, Dec, Jan, Feb, and Mar), while adjusting for potential confounders. Stratified analyses were performed for sex and age groups.
Results: Ambulance calls peaked at 10am for all groups, except those aged <15 years at 19pm, while temperature was hottest at 13pm. The hourly heat-ambulance calls relationships were non-linear for all groups, with thresholds between 27 °C and 31 °C. The associations appeared immediately, and lasted for about 24 h. There were no significant modification effect by sex and age.
Conclusions: The findings suggest that hot hourly temperatures (>27 °C) increase the demands of ambulance. This information is helpful to increase the efficiency of ambulance service then save lives, for example, preparing more ambulance before appearance of extremely hot temperature in combination with weather forecast. Also, people should better arrange their time for outdoor activities to avoid exposing to extreme hot temperatures.

1. Introduction

There has been increasing interests in assessing the impacts of heat on human health, as climate change will increase the global mean temperature, and increase the frequency, duration, and intensity of heatwaves (Moss et al., 2010). Understanding heat-related health issues is important for development of public health policy and improvement of health services that seeks to minimise the adverse health impacts of extreme hot temperatures (Huang et al., 2013). To date, many studies have examined the heat effects on mortality/morbidity (hospital admission and emergency hospital visits) in different cities/regions/countries, with daily time series data (Gasparrini et al., 2015; Guo et al., 2014; Ye et al., 2012). Such kind studies have played an important role to understand the heat effects on health and to develop public policies regarding health protection. However, using daily data might miss the very short-term heat effects (exposure within few hours) (Bhaskaran et al., 2011). There is no doubt that assessment of the hourly heat effects on health outcomes can be used for improvement of public health or clinical guidelines, but limited evidence is available due to limited hourly health data (Bhaskaran et al., 2012).

Data on ambulance calls (including information of calling time) is a good candidate to examine the hourly heat-health associations (Yorifuji et al., 2014). There are lots of benefits from assessing hourly heat impacts on ambulance calls, from the ability to conduct more targeted health intervention strategies, to the development of precise early heat-warning systems (Bassil et al., 2008). Importantly, it is helpful to increase the response speed of ambulance calls which is very crucial to rescue patients suffering immediately life threatening conditions (Thornes et al., 2014). However, no study has examined the hourly associations between heat and ambulance calls, although some studies show daily hot temperatures increase rates of daily ambulance attendances (Turner et al., 2012; Wong

☆ This paper has been recommended for acceptance by David Carpenter.

* Room 229, Public Health Building, University of Queensland, Herston Rd, Herston, QLD 4006, Australia.
E-mail address: y.guo1@uq.edu.au.

http://dx.doi.org/10.1016/j.envpol.2016.10.091
0269-7491/

and Lai, 2014).

2. Material and methods

This study was conducted in Brisbane, the capital city of Queensland, Australia. Brisbane is located on the east coast of Australia (27° 30′ south and 153° 00′ east), and has a subtropical climate and generally experiences mild winters and hot summers.

2.1. Data on ambulance calls

Data on ambulance attendance were collected from the Queensland Ambulance Service during 2001 and 2007. Queensland Ambulance Service is the main provider of ambulance transport and out-of-hospital emergency in Brisbane. Only data on Australian citizens and permanent residents were used in this study. The data extracted from each anonymised attendance record include the time of ambulance calls (including hour and date), sex and age of the patient, and the health assessment of the patient recorded using the 10th revision of International Classification of Diseases (ICD10). Ethical approval was obtained prior to the collection of these data.

In this study, ambulance calls for non-accidental causes were extracted for analysis, as it is assumed that accidental attendance may be not related to ambient temperature exposure. To investigate effects of heat specifically, the analysis was restricted to the warm season (November, December, January, February, and March).

2.2. Environmental exposure data

Hourly meteorological data (temperature and humidity) and hourly data of concentrations of air pollutants [ozone (O_3), nitrogen dioxide (NO_2), and particulate matter of size <10 μm (PM_{10})] were obtained from the Department of Environment and Resource Management from eight monitoring sites throughout Brisbane during the study period. Hourly mean values were then calculated for all meteorological and environmental data; when a particular station had missing data, the average across the remaining stations was calculated.

2.3. Statistical analysis

A time-stratified case-crossover design was used to examine the associations between heat and ambulance calls. The case-crossover study is a type of self-matched case-control study (Maclure, 1991). For each individual, exposure information are collected for the "case" period and a series of "control" periods that were not associated with the event of interest. The case-crossover design was used to compare the individual's temperature exposure directly before his/her ambulance calls to the exposure at other times when he/she did not call ambulance. For the time-stratified case-crossover design, control periods should be selected from the fixed time strata as the source of control days, which avoids any "overlap bias" (Janes et al., 2005). In addition, by comparing exposure preceding the ambulance calls with exposure on hours shortly before and after the ambulance calls in the same time strata, the seasonal trends can be successfully controlled for.

In this study, the calendar month was used as fixed time strata and control periods comprised the same hour of the same day of the week in the calendar month of ambulance calls, to control for the effect of day of the week and intra-day variation (Fig. 1). The conditional logistic regression model was used to fit the time-stratified case-crossover design, which successfully controlled for time-invariant individual level confounders (e.g., smoking and weight), because comparisons between case and control periods were made within individuals. The association between ambient temperature and risk of ambulance calls was examined by using a distributed lag non-linear model (DLNM), allowing for delayed effects of up to 10 days (0–240 h). The reason for choosing lag periods of up to 10 days was to fully capture the potential lag period, as previous daily time series studies have observed heat mortality/morbidity associations lasted for 1–3 days (Guo et al., 2014). A nature cubic spline with 4 degrees of freedom was used for both temperature and lag hours, as the initial analysis showed it produced best model fit as judged by lowest value of Akaike Information Criterion (AIC). To fully adjust for the other potential time-variant confounders, PM_{10}, NO_2, O_3, and relative humidity were controlled in all models by natural cubic splines with 4 degrees of freedom for their 0–72 h mean values.

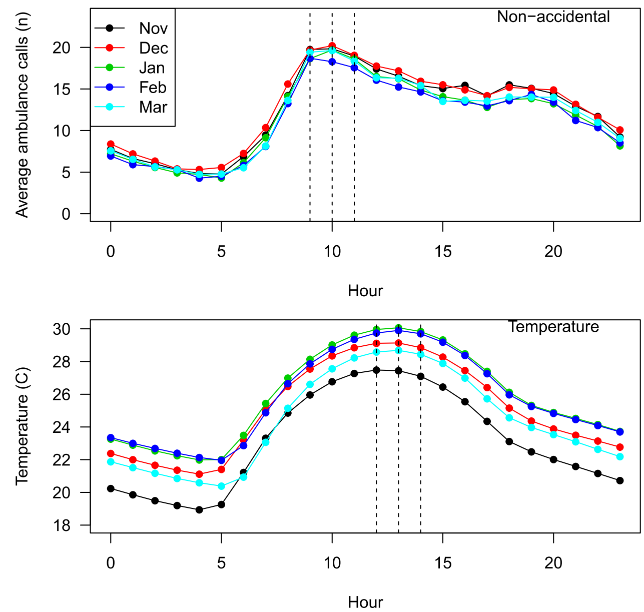

Fig. 1. The average hourly counts of ambulance calls for non-accidental causes and the average hourly temperature in five warm months (Nov, Dec, Jan, Feb, and Mar) in Brisbane, during 2001 and 2007.

To assess the possible modification effects of demographic factors on the associations between heat and ambulance calls, stratified analyses were conducted for sex and age groups (<15, 15–34, 35–64, and ≥65 years). A meta-regression was used to test the statistical difference between effect estimates for subgroups (e.g., men VS women) (Li et al., 2016; Yang et al., 2015). For instance, the effect estimates of stratum-level analyses (e.g., men and women) were put as dependent variable in the meta-regression, while the predictor (men and women) were put as independent variable. The likelihood ratio test was used to examine whether the effect estimates between men and women were statistically different or not.

In order to better inform the public health policy and to improve the ambulance service, the thresholds of heat-ambulance calls associations were examined for each group. First, potential range of thresholds was visually checked by plotting the graph of the relationship between heat and ambulance calls. Then AIC values for conditional logistic regression models were iteratively examined by 1 °C increment in temperature within the identified range of thresholds using the segment spline model. The temperatures corresponding to the lowest AIC values were chosen as the thresholds. This method has been widely used to test thresholds in the temperature-mortality associations using daily time series data (Guo et al., 2011).