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Effects of ambient temperature on myocardial infarction: A systematic review and meta-analysis☆

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ABSTRACT

Previous studies have suggested that ambient temperature is associated with the mortality and morbidity of myocardial infarction (MI) although consistency among these investigations is lacking. We performed a meta-analysis to investigate the relationship between ambient temperature and MI. The PubMed, Web of Science, and China National Knowledge Infrastructure databases were searched back to August 31, 2017. The pooled estimates for different temperature exposures were calculated using a random-effects model. The Cochran's Q test and coefficient of inconsistency (I^2) were used to evaluate heterogeneity, and the Egger's test was used to assess publication bias. The exposure-response relationship of temperature-MI mortality or hospitalization was modeled using random-effects meta-regression. A total of 30 papers were included in the review, and 23 studies were included in the meta-analysis. The pooled estimates for the relationship between temperature and the relative risk of MI hospitalization was 1.016 (95% confidence interval [CI]: 1.004–1.028) for a 1 °C increase and 1.014 (95% CI: 1.004–1.024) for a 1 °C decrease. The pooled estimate of MI mortality was 1.639 (95% CI: 1.087–2.470) for a heat wave. The heterogeneity was significant for heat exposure, cold exposure, and heat wave exposure. The Egger's test revealed potential publication bias for cold exposure and heat exposure, whereas there was no publication bias for heat wave exposure. An increase in latitude was associated with a decreased risk of MI hospitalization due to cold exposure. The association of heat exposure and heat wave were immediate, and the association of cold exposure were delayed. Consequently, cold exposure, heat exposure, and exposure to heat waves were associated with an increased risk of MI. Further research studies are required to understand the relationship between temperature and MI in different climate areas and extreme weather conditions.

1. Introduction

Myocardial infarction (MI), commonly known as a heart attack, is caused by an atherosclerotic plaque rupture, which leads to partial or complete thrombotic vessel occlusion. It is one of the leading causes of cardiovascular mortality, accounting for 15.5% of total deaths according to the Global Burden of Disease 2015 report (Global Health Estimates, 2015). The factors that trigger MI have become a hot research topic in recent years, with many epidemiological studies showing that it is affected by changes in ambient temperature (Nawrot et al., 2011; Lipovetzky et al., 2007; Abrignani et al., 2009). Changes in global climate have resulted in the increased frequency, duration, and intensity of extreme weather; thus, it is essential to determine the effects of ambient temperature on MI to reduce its global health care burden.

While several studies have investigated the effects of temperature change on the risk of MI, the results have been inconsistent. Many studies have described a U- or V-shaped relationship between temperature and MI, but very few have examined the relationship between temperature and MI for a specific temperature range (hot season, cold season, above a threshold temperature or below a threshold temperature), and thus only found positive or negative associations (Claeys et al., 2015; Danet et al., 1999; Sen et al., 2015; Gasparrini et al., 2011; Koken et al., 2003; Wichmann et al., 2012; Radišauskas et al., 2013; Lim et al., 2012). Other investigations have shown that low temperature is associated with higher mortality and hospitalizations related to MI (Claeys et al., 2015; Danet et al., 1999), and that high temperature increases the

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risk of MI (Sen et al., 2015; Gasparrini et al., 2011; Koken et al., 2003). However, small sample sizes have revealed opposing association between heat exposure and MI (Wichmann et al., 2012; Radišauskas et al., 2013), whereas other investigations have demonstrated a non-significant association between these two factors (Lim et al., 2012). It has also been shown that extreme temperature (heat waves or cold spells) can increase the mortality and hospitalization of patients with MI (Åström et al., 2015; Zhong et al., 2010). Because data on the association of temperature on MI have been inconsistent (Bhaskaran et al., 2009), it is necessary to conduct a systematic review and meta-analysis to determine the relationship between ambient temperature and MI by pooling the evidence from relevant epidemiological studies.

2. Methods

This meta-analysis followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement and the Meta-analysis of Observational Studies in Epidemiology criteria for reporting (Moher et al., 2009; Stroup et al., 2000).

2.1. Search strategy and study selection

We performed a systematic literature search of the PubMed, Web of Science, Embase, and China National Knowledge Infrastructure (CNKI) databases through August 31, 2017. The search strategies were based on combinations of keywords related to ambient temperature (temperature, heat, hot, warm, heat wave, cold, cold spell, season, climate, weather, atmosphere) and MI (ischemic heart disease, myocardial ischemia, cardiac ischemia, coronary heart disease, heart disease, vascular disease, cardiovascular diseases) and death (hospitalization, mortality, morbidity, emergencies) (detailed search strategies are listed in Supplemental Table 1). The search was limited to studies on adult humans, published in both English and Chinese. We performed equivalent searches in Embase, Web of Science, and CNKI (using keywords for all). References in each identified paper were also examined to determine if any paper was missed in the electronic database searches. Based on the ambient temperature exposure used in each study, we divided the investigations into four types: heat exposure, cold exposure, heat waves, and cold spells. Studies in the heat exposure category described the number of degrees above the defined threshold or average value or a comparison between extreme hot conditions and the reference value. Studies in the cold exposure category described the number of degrees below the defined threshold or average value or a comparison between extreme cold conditions and the reference value. Studies were placed in the heat wave category if exposure was two or more days exceeding the defined temperature (e.g., 95th percentile). Studies were placed in the cold spell category if the temperature remained below the defined temperature (e.g., 5th percentile) for two or more days. The study screening process is shown in Fig. 1. Studies presenting original data, population-based, and observational studies, studies in which the exposure indicator was ambient temperature (including heat exposure, cold exposure, heat waves, and cold spells), studies in which the outcome specifically included MI, and studies that provided quantitative evaluations including relative risk (RR), odds ratio (OR), or hazard ratio (HR) were included in the present analysis. Studies were excluded if they only examined broader cardiovascular disease outcomes but did not specifically consider MI, were reviews or commentaries, were animal based, toxicological, or intervention studies, or only included qualitative evaluations. Studies that met the inclusion criteria were identified by reviewing the titles and abstracts, followed by a review of the full text. Two investigators independently processed the data from each eligible study prior to conducting the meta-analysis.

2.2. Quality assessment

For relevant papers, we evaluated the study quality using the Newcastle–Ottawa Scale (NOS) including study group selection (four points), comparability of groups (two points), and ascertainment of either the exposure or outcome of interest (three points) for case-control or time series studies, respectively (Lo et al., 2014). The NOS assigns up to a maximum of nine points, with a higher score indicating higher quality.

2.3. Data extraction

The data extracted from the studies included the last name of the first author, publication year, study period, location and country in which the study was performed, study design, temperature measures as exposure variables, lag effects, population, esimates, and 95% confidence interval (CI) and controlled variables (i.e., day of week, holiday, and season). All risk estimates were converted into a common exposure unit of a 1 °C change in temperature, which allowed us to quantitatively pool estimates from different studies.

2.4. Data analysis

The statistical analysis involved three steps: calculating the pooled estimates for each type of temperature exposure using a random-effects model; performing a meta-regression based on temperature, latitude, and lag days; and conducting a sensitivity analysis. In the first step, a meta-analysis was used to pool the estimates of RR from all of the included studies. Considering the heterogeneity from the study designs, methods of temperature measurement, geographical location, population characteristics, and lag pattern between studies, a random-effects model was applied to calculate the pooled estimates if the index of heterogeneity (I^2) was >25%; otherwise, we chose the fixed effects model (Borenstein et al., 2010). Results were calculated from the pooled maximum estimate of each study. If the study was performed at different locations, we included the maximum estimate of each location. Heterogeneity among studies was quantified using Cochran's Q-statistics by summing the squared deviations of each study's estimate from the overall meta-analysis estimate and weighting each study's contribution in the same manner as in the meta-analysis. $P < 0.05$ was deemed statistically significant. However, Q-statistics are susceptible to the number of studies in the meta-analysis. Therefore, we combined the coefficient of inconsistency (I^2) and Q-statistics to estimate the heterogeneity (Higgins et al., 2003). The heterogeneity was categorized as high ($I^2 \geq 75\%$), moderate ($25\% < I^2 < 75\%$), or low (I^2) (Nawrot et al., 2011). Funnel plots and Egger tests were used to evaluate the potential effects of publication bias (Egger and Minder, 1997). In the second step, to further investigate the heterogeneity, we performed a meta-regression analysis, and modeled the effect sizes by changes in temperature, lag days, and latitude. The reason we chose these three variables for meta-regression was referred to in a recent paper, and the data from these three variables were available (Phung et al., 2016). Separate analyses were performed on studies related to different temperature exposures (heat exposure, cold exposure, heat waves, cold spell) using random-effects regression with the empirical Bayesian technique. In the third step, to examine the robustness of the findings, sensitivity analyses were performed. Because the range of lag days was different in the heat and cold exposure groups and the effects of heat exposure were immediate,