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Extreme temperature and out-of-hospital cardiac arrest in Japan: A nationwide, retrospective, observational study

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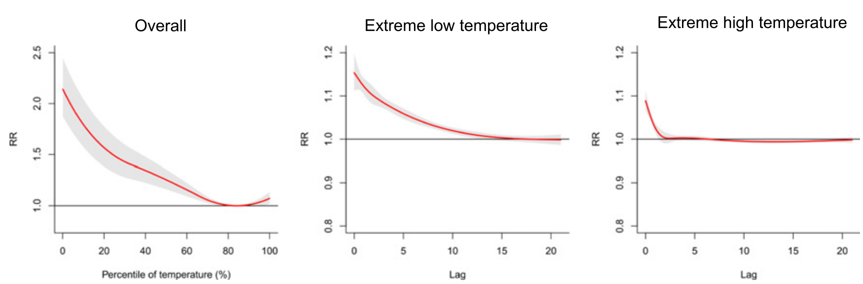
HIGHLIGHTS

- Low as well as high temperatures show effects on OHCA.
- Extremely high and low temperatures are associated with OHCA.
- Heat effects were acute and disappeared after a few days.
- Cold effects were also acute, but persisted for several days.
- There was no spatial heterogeneity among prefectures.

GRAPHICAL ABSTRACT



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ABSTRACT

Background: Although several studies have estimated the effect of extreme temperatures on out-of-hospital cardiac arrest (OHCA) in a single city or region, few have investigated variations in this association on a national level in Japan.
Methods: Daily data on OHCAs and weather variations were obtained from the 47 prefectures of Japan between 2005 and 2014. A time-series Poisson regression model with a distributed lag non-linear model was used to estimate the prefecture-specific effects. A multivariate meta-analysis was applied to pooled estimates on a national level.
Results: A total of 659,752 OHCA cases of presumed-cardiac origin met the inclusion criteria. The minimum morbidity percentile (MMP) was identified as the 84th percentile for temperature, ranging from 20.8 °C in Hokkaido to 28.8 °C in Okinawa. The overall pooled relative risk versus the MMP was 2.10 (95% CI: 1.84, 2.40) at extremely low temperatures (1st percentile) and 1.06 (95% CI: 1.01, 1.12) at extremely high temperatures (99th percentile). The effects of extremely high temperatures were acute and disappeared after a few days, while those of extremely low temperatures were also acute, but persisted for several days. The multivariate Cochran's Q test indicated no heterogeneity between prefectures ($p = 0.699$; $I^2 = 1.0\%$).
Conclusions: Extreme temperatures are associated with an increased risk of OHCA. Timely prevention strategies might reduce the risk of OHCA during extreme temperatures. Several days prevention should be also implemented for extremely low temperatures.

1. Introduction

Recent studies have provided evidence of an association between ambient temperature and morbidity or mortality (Basu and Samet, 2002; Ye et al., 2012). These weather-related outcomes are expected to increase commensurately as periods of extreme temperature

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increase in frequency, intensity, and duration due to climate change (Le Tertre et al., 2006; Semenza et al., 1996; Stocker et al., 2014). Although extremely high and low temperatures adversely affect the health of people in the affected area, there are inconsistencies in the direction and magnitude of non-linear lag effects (Basu and Samet, 2002; Le Tertre et al., 2006; Semenza et al., 1996; Stocker et al., 2014; Ye et al., 2012). A number of studies have investigated the impact of temperature on major health outcomes (Basu and Samet, 2002; Le Tertre et al., 2006; Semenza et al., 1996; Stocker et al., 2014; Ye et al., 2012). However, to our knowledge, few quantitative studies have investigated the risk of out-of-hospital cardiac arrest (OHCA) related to extreme temperatures.

Extremely hot and cold temperatures are reportedly associated with cardiovascular mortality and morbidity. Emerging evidence suggests that extreme temperatures might be an important risk factor for OHCA (Empana et al., 2009). In addition, previous studies have indicated that sudden cardiac death and out-of-hospital coronary death show remarkable seasonal variation, with a significant increase in winter (Arntz et al., 2000; Nakanishi et al., 2011; Toro et al., 2010). In the United States, cold temperatures were found to significantly increase the risk of out-of-hospital cardiac or sudden coronary mortality (Cagle and Hubbard, 2005; Gerber et al., 2006). Moreover, a recent multi-city study conducted in China suggested that extremely hot and cold temperatures significantly increased the risk of out-of-hospital coronary mortality (Chen et al., 2014). However, most studies have only examined the effects of temperature in a single city or region, and are therefore not necessarily extend to the national level. Further, previous studies have demonstrated distinct non-linear relationships between temperature and cardiovascular morbidity, in which the morbidity-modifying effects of temperature were spatially heterogeneous (Turner et al., 2012). To our knowledge, however, no study has assessed a diverse range of communities exposed to a variety of climatic conditions. Therefore, elucidating the complex, non-linear, and multi-parameter relationship between climate variation and OHCA on a national scale is essential.

Multivariate meta-regression analysis with distributed lag non-linear models helps to estimate and pool non-linear and delayed associations from multiple locations (Gasparrini and Armstrong, 2013; Gasparrini et al., 2012). This two-stage modeling approach reduces over-simplification of the exposure-response relationship or lag structure and can be applied to any context requiring assessment of non-linear and delayed relationships within different sub-groups or populations (Gasparrini and Armstrong, 2013; Guo et al., 2014). The majority of previous studies have been based on conventional linear or linear-threshold assumptions and univariate meta-analysis approaches, which cannot describe complex non-linear relationships and may exclude important variables. Thus, a more comprehensive understanding using the two-stage analysis of weather variables might help to facilitate the development of a reliable early warning system to predict OHCA.

Here, we used national OHCA data collected between 2005 and 2014 in Japan to investigate the associations between extreme temperatures and daily reports of OHCA throughout the 47 prefectures of Japan. To our knowledge, this is the first nationwide study to investigate the effects of temperature on the risk of OHCA using a two-stage time series analysis.

2. Methods

2.1. Study design and subjects

This retrospective observational study used national registry data. The patients were aged 18 to 110 years and had OHCA of presumed cardiac origin before the arrival of emergency medical service (EMS) personnel between January 1, 2005 and December 31, 2014 in Japan. Patients were treated by EMS personnel and were transported to medical institutions.

This study was approved by the ethics committee at Kyushu University Graduate School of Medical Sciences. The requirement for written informed consent was waived. Patient records and other patient information remained anonymous and de-identified prior to analysis. All methods were conducted in accordance with approved guidelines and regulations.

2.2. EMS and data collection

Detailed information on the EMS system in Japan is published elsewhere (Kitamura et al., 2010; Ogawa et al., 2011). Briefly, municipal governments provide EMS via approximately 800 fire stations with transportation centers under the Fire Service Act. As EMS providers are not allowed to terminate resuscitation in the field, all patients with OHCA who are treated by EMS personnel are then transported to hospitals.(Council, 2007) Following the standardized Utstein-style reporting guidelines for cardiac arrest, the EMS personnel summarize each case of OHCA in cooperation with the physicians in charge (Cummins et al., 1991). Data from the 800 fire stations with dispatch centers in the 47 prefectures are then sent to the Fire and Disaster Management Agency (FDMA) and integrated into the national registry system on the FDMA database server. In a nationwide, and population-based manner, the FDMA has collected data regarding all OHCA cases using a standardized Utstein-style format. In Japan, registration of OHCA data is required under the Fire Service Act and is considered to have a same validity and completeness between prefectures and different years. We obtained data on daily minimum, mean and maximum temperatures, and relative humidity from 47 prefectures of Japan. Daily minimum, mean and maximum temperatures, and relative humidity were calculated as the 24-hour average based on hourly measurements, and obtained from the Japan Meteorological Agency. A single weather station located within the urban area of the capital city was selected as a representative of the region for each prefecture because these were synoptic climatological stations and intended to capture macro-scale weather for each prefecture (Supplementary Fig. S1). Daily mean temperature was selected as the main exposure index, as it reflects exposure over 24 h and provides easy-to-interpret data for decision-making purposes (Guo et al., 2011; Guo et al., 2014; Guo et al., 2012).

2.3. Statistical analysis

2.3.1. First-stage time series model

A time series regression model based on a generalized linear model assuming a quasi-Poisson distribution was first applied to obtain prefecture-specific temperature-morbidity relationships. In this first-stage regression, the non-linear and delayed effect of temperature was modeled using distributed lag non-linear models for each prefecture (Gasparrini and Armstrong, 2013; Gasparrini et al., 2012). A natural cubic B-spline was used to define a cross basis function for temperature as well as for the lag space, with a maximum lag period of up to 21 days. The natural cubic B-spline basis was set using 4 degrees of freedom for temperature and lag. The choice of lag periods of up to 21 days was motivated by previous studies suggesting that effects of cold temperatures were more delayed and lasted for a few weeks, while the effects of high temperatures were more acute and possibly affected by harvesting effect (Gasparrini and Armstrong, 2013; Guo et al., 2014). A categorical variable for day of the week, and an indicator variable for public holidays, were included in the model because previous studies suggested that these are potential confounding factors for OHCA (Bagai et al., 2013; Kitamura et al., 2014; Wallace et al., 2013).

Prefecture-specific temperature-morbidity associations are generally evaluated using an absolute temperature scale. However, temperature ranges differ among Japan's 47 prefectures, hampering the combination of curves across prefectures using non-overlapping temperature ranges. In addition, due to adaptation to climate change among populations, we hypothesized that overall effects would be more reliable in terms of temperature percentiles than absolute temperature scales. The overall effects of temperature on morbidity were therefore evaluated using a relative temperature scale with percentiles of the prefecture-specific mean temperature distribution.

Prefecture-specific parameters of the cross-basis function were expressed as the non-linear and delayed temperature-morbidity association of each prefecture. This was then reduced to three summaries expressing the overall cumulative exposure-response relationship and the lag-response association specific to the 1st and 99th percentiles. The 1st percentile represented the lag pattern of lower temperatures and the 99th percentile represented that of higher temperatures. Each summary was reduced by computing transformed parameters for the unidimensional natural cubic B-splines for temperature or lag space using the original parameters above, as previously described (Gasparrini and Armstrong, 2013).

The prefecture-specific Poisson time-series model is described by the following Eq. (1):

$$\log\left[E(Y)\right] = \alpha + cb + dow + hol + NS\,(time, df) \tag{1}$$

where $E(Y)$ denotes expected daily morbidity, cb the cross basis matrix for mean daily percentile temperature, dow the categorical variable for day of the week, hol the indicator variables for public holidays, NS $(time, df)$ the natural cubic spline of time, and df the degrees of freedom for time, with 10 df per year used to control for the effects of seasons and long-term trends as based on a previous study (Guo et al., 2014).

2.3.2. Second-stage meta-analysis

Estimated prefecture-specific associations were pooled using multivariate meta-regression models obtained following the reduction of the first stage to evaluate the non-linear temperature-morbidity relationship at the national level (Gasparrini and Armstrong, 2013). Multivariate meta-regression analyses were applied to examine national pooled estimates using a random effects model according to maximum likelihood. Random effects model was used to allow for the potential degree of heterogeneity between prefectures. Total heterogeneity in temperature-OHCA associations between prefectures was tested and evaluated by the multivariate extension of the Cochran's Q test and the I^2 index, which quantifies the percentage of variability due to true differences across prefectures (Gasparrini et al., 2012; Higgins and Thompson, 2002). Additionally, the heterogeneity in temperature-OHCA curves may be partly explained as effect modification by prefecture-specific factors (Gasparrini and Armstrong, 2013). To account for the effect modification attributed to different temperature distributions between prefectures, prefecture-specific latitude, mean temperature and temperature range were also included as additional meta-predictors. The effect modification was tested by using the multivariate Wald test.

Fitted multivariate meta-regression models were used to derive the best linear unbiased prediction of the overall cumulative exposure–response association for each prefecture. The best linear unbiased prediction represents a trade-off between the prefecture-specific association, provided by the first-stage regression, and the pooled association (Gasparrini et al., 2012; Gasparrini et al., 2015). Minimum morbidity temperature was derived from the best linear unbiased prediction of the overall cumulative exposure–response association in each prefecture. This value was referred to as the optimum temperature and used as a reference to recenter the quadratic B-spline and calculate risk, as previously described (Gasparrini et al., 2015; Gasparrini and Leone, 2014).

For sensitivity analysis, temperature-morbidity relationships were estimated by using different degrees of freedom for time trends (8 and 9 degrees of freedom per year) or by including relative humidity. All analyses were performed using the R software package (ver. 3.2.2; R Core Team, R Foundation for Statistical Computing, Vienna, Austria) with the *dlnm* and *mvmeta* packages.

3. Results

Of 1,176,351 OHCA cases between January 1, 2005 and December 31, 2014 among the 47 prefectures of Japan, 659,752 cases of OHCA of presumed-cardiac origin met the inclusion criteria. The number of OHCA cases and mean temperature showed marked variations by prefecture, consistent with the diverse range of climactic conditions in Japan (Supplementary Table S1).

Fig. 1 shows the pooled overall cumulative relationships between the relative risk (RR) of OHCA and temperature. The minimum morbidity percentile (MMP) was identified as the 84th percentile for temperature, with prefecture-specific means ranging from 20.8 °C in Hokkaido to 28.8 °C in Okinawa. Risk of OHCA generally increased slowly and linearly below the cutoff temperature. Extremely high and low temperatures were associated with an increased risk of OHCA (Fig. 1). The overall pooled RR versus the MMP was 2.10 (95% CI: 1.84, 2.40) at extremely low (1st percentile) temperatures and 1.06 (95% CI: 1.01, 1.12) at extremely high (99th percentile) temperatures. The multivariate Cochran's Q test indicated no heterogeneity between prefectures ($p = 0.699$; $I^2 = 1.0\%$).

Fig. 2 shows pooled estimates of predictor-specific summary associations at the 1st and 99th percentiles for temperature based on the main model. The effects of extremely high temperatures began immediately and disappeared after 2 to 3 days. The effects of extremely low temperatures also began immediately, and subsequently persisted over 10 days. There was no significant heterogeneity between prefectures for the lag curve at the 1st temperature percentile (Cochran's Q test, $p = 0.391$; $I^2 = 2.3\%$) or at the 99th temperature percentile (Cochran's Q test, $p = 0.887$; $I^2 = 1.0\%$).

Fig. 3 shows the results of the meta-regression analysis. The top panel suggests a differential overall cumulative association between the northern and southern prefectures. Overall, the effect modification in temperature-OHCA associations was significant for prefecture-specific latitude ($p < 0.001$) and mean temperature ($p = 0.029$), but not for temperature range ($p = 0.128$). The multivariate I^2 statistic suggested that 1.0% of the variation in temperature-OHCA association was attributable to true heterogeneity among prefectures (Cochran's Q test, $p = 0.944$). The bottom panels indicate an identical modifying effect in predictor-specific summary associations at the 1st and 99th temperature percentiles. The effect modification of latitude was substantial for extremely low temperatures ($p = 0.004$), with a higher effect in southern prefectures; whereas the identical modifying effect was not

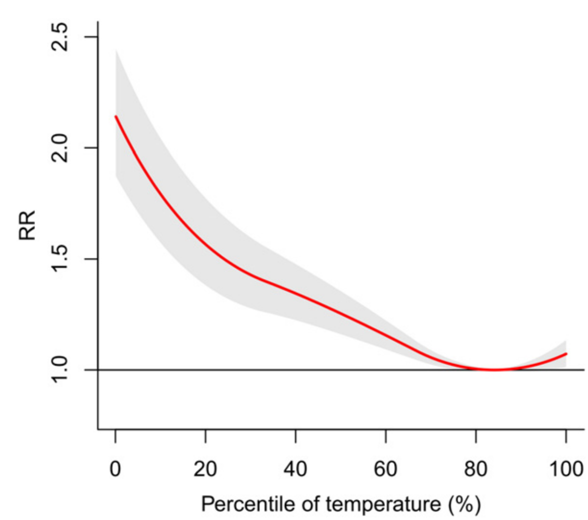

Fig. 1. The pooled overall cumulative temperature-morbidity association in all 47 Japanese prefectures. Reference is at the 84th percentile for temperature.

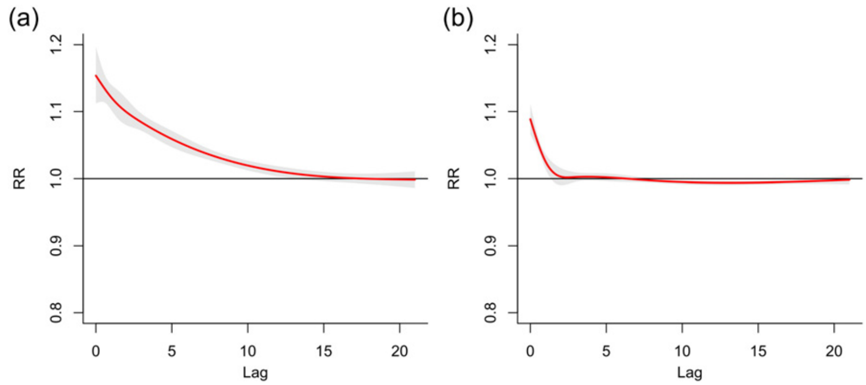

Fig. 2. The pooled predictor-specific temperature-morbidity association in all 47 Japanese prefectures. The pooled (95% CI as grey area) summaries at (a) low (1st percentile) and (b) high (99th percentile) temperatures.

observed for extremely high temperatures ($p = 0.866$). Prefecture-specific mean temperature and temperature range showed no significant effect modification for extremely cold and high temperatures (all $p > 0.1$). There was no significant heterogeneity for the lag curve at the 1st temperature percentile (Cochran's Q test, $p = 0.664$; $I^2 = 1.0\%$) or at the 99th temperature percentile (Cochran's Q test, $p = 0.893$; $I^2 = 1.0\%$).

To investigate whether the results were sensitive to the level of control exercised for time trends, analyses were repeated using different degrees of freedom or by including relative humidity. The estimated effects of temperature showed only marginal changes (Supplementary Table S2).

4. Discussion

We observed substantial variation in the effect of extreme temperatures on the risk of OHCA in Japan. Both extremely high and low temperatures were associated with an increased risk of OHCA, with non-significant heterogeneity between prefectures. The effects of both extremely high and low temperatures on the risk of OHCA began immediately. However, the effects of extremely high temperatures disappeared after a few days, whereas those of extremely low temperatures persisted for several days. There was no significant heterogeneity at extremely high and low temperatures. These findings indicate that extreme temperatures have a significant impact on the risk of OHCA.

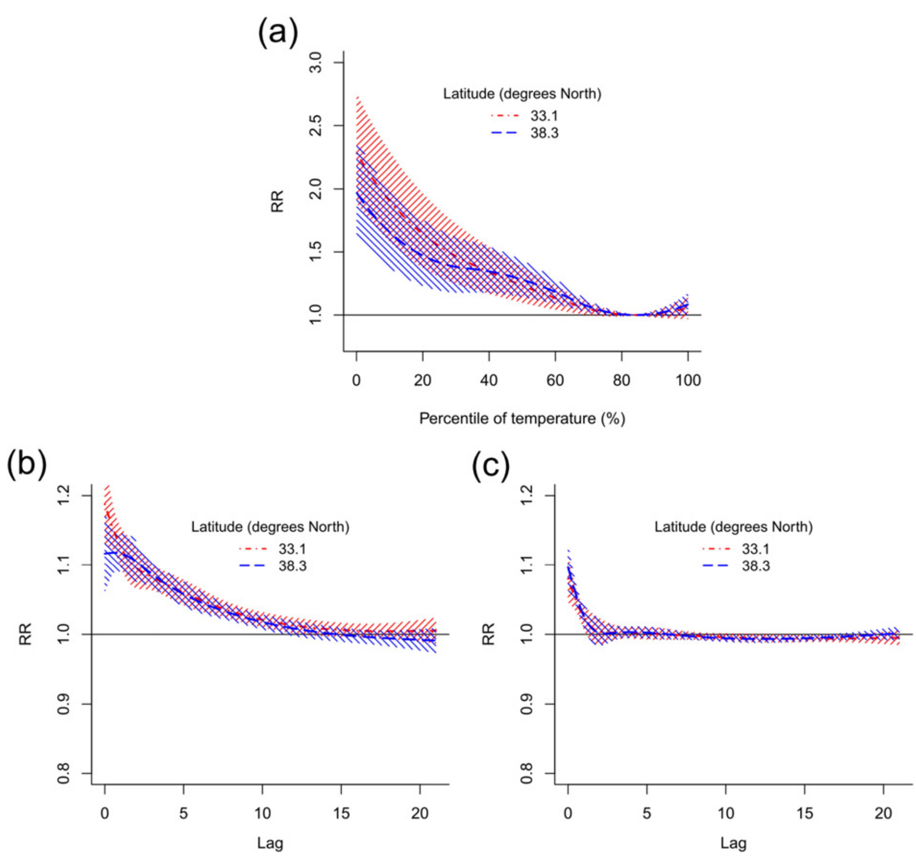

Fig. 3. The pooled temperature-morbidity association by latitude in all 47 Japanese prefectures. Predictions for the 10th (dot-dashed line) and 90th (dashed line) percentiles of latitude from meta-regression for (a) overall cumulative summary, and predictor-specific summaries at (b) low (1st percentile) and (c) high (99th percentile) temperatures.

We found that extremely high temperatures were associated with an increased risk of OHCA and that their effect was immediate and disappeared within a few days. These results are consistent with a recent multi-city study conducted in China, which suggested that extreme heat significantly increased the risk of out-of-hospital coronary mortality (Chen et al., 2014). In the United States, positive associations between high temperature and cardiovascular-related emergency department visits were reported for ischemic heart diseases, ischemic stroke, cardiac dysrhythmia, hypotension, diabetes, intestinal infection, dehydration, acute renal failure, and heat illness (Basu et al., 2012). Sudden increases in ambient temperature are also associated with increased cardiovascular disease mortality (Basu, 2009). In contrast, the findings of a study of 12 European cities indicated that the association between high temperatures and cardiovascular hospitalizations tended to be negative and not significant (Michelozzi et al., 2009). Negative associations between high temperatures and emergency department visits have been reported for aneurysm, hemorrhagic stroke, and hypertension in the United States (Basu et al., 2012). Another study found that the risk of hospitalization for congestive heart failure was lower during extreme heat events (Bobb et al., 2014), and a recent systematic review found no effect of extremely high temperatures on cardiovascular morbidity (Turner et al., 2012). These results suggest that cardiovascular diseases are comprised of many subtypes that may be affected by extremely high temperatures in a number of different ways (Lin et al., 2009). As high temperatures are associated with the activation of coagulation, they are considered to have both systemic and cardiac effects (Bouchama and Knochel, 2002; Kahle et al., 2015; Meyer et al., 2013). Although the physiological mechanism underlying the association between extremely high temperatures and cardiovascular events remains unclear, our findings highlight the need for further investigation into the effects of extremely high temperature on cardiovascular diseases.

Our analyses also demonstrated that extremely low temperatures significantly increased the risk of OHCA. Our results are consistent with a recent multi-city study in China, which suggested that extremely cold temperatures significantly increased the risk of out-of-hospital coronary mortality (Chen et al., 2014). Another recent study suggested that extremely low temperatures increased the risk of emergency department visits for cardiovascular disease in comorbid cardiac disease patients (Lavigne et al., 2014). A potential mechanism to explain the increased risk for OHCA in association with extremely low temperatures includes the stimulation of cold receptors in the skin and therefore the sympathetic nervous system, which elicits an increase in catecholamine levels (Wolf et al., 2009). Subsequent vasoconstriction causes an increase in heart rate and blood pressure. Moreover, cold temperatures could be related to an increase in thrombogenic factors such as blood cell counts, plasma cholesterol, C-reactive protein, plasma fibrinogen concentration, and platelet viscosity, as well as decreased high-density lipoprotein cholesterol levels in patients with comorbid cardiac disease (Baccini et al., 2008; Halonen et al., 2010; Hong et al., 2012; Wolf et al., 2009). Further, a high risk of heart failure, arrhythmia, and atrial fibrillation has also been reported in periods of extremely low temperatures (Medina-Ramon et al., 2006; Stafoggia et al., 2006). Thus, our findings are physiologically plausible.

Our pooled analyses of predictor-specific associations showed that the effects of both extremely high and low temperatures were acute at the national level. The effects of extremely high temperatures disappeared after a few days, but those of extremely low temperatures persisted over several days. Our finding of the lag pattern in extreme temperature-related OHCA is consistent with previous studies. For example, in a study of 12 cities in the United States, the effects of high temperatures on hospital admissions for heart disease appeared immediately, whereas the effects of extremely cold temperatures were delayed (Schwartz et al., 2004). In the metropolitan area of Adelaide, hospital admissions of patients with ischemic heart disease increased during heatwaves (Nitschke et al., 2007), and in New York City, extremely high temperatures increased the risk of cardiovascular-related hospital admissions over a lag period of up to 3 days (Lin et al., 2009). Similar patterns of time lag have also been reported in previous studies investigating mortality (Anderson and Bell, 2009; Gasparrini and Armstrong, 2013; Goodman et al., 2004; Guo et al., 2014). The complex lag pattern that we observed might be due to differences in OHCA subtypes. Our results suggest that timely preventive measures could reduce the risk of OHCA at both high and low temperature extremes, and measures allowing for several days of protection should be implemented to reduce the risk of OHCA during periods of extremely low temperatures.

From the meta-regression analysis, the effect modification of latitude was observed for overall cumulative temperature-OHCA association. The effect modification of latitude was substantial for extremely low temperatures, with a higher effect in southern prefectures, but not for extremely high temperatures. Our results are consistent with recent studies, which suggest that population in the southern regions are more vulnerable to cold-related cardiovascular disease mortality (Yang et al., 2015). In contrast, a previous meta-analysis indicated that latitude had little effect on cardiovascular morbidity (Turner et al., 2012). These discrepancies in findings between studies could be related to latitude differences in socioeconomic status, population demographics, geographical factors, underlying disease risk, vulnerable subpopulations, physiological acclimatization, access to public health and emergency care services, and local adaptations in addition to weather patterns.

Meta-analysis results also indicated that there was no significant heterogeneity between prefectures. The most likely explanation for our findings is that composite outcomes for cardiovascular diseases and different physiological mechanism on the circulatory system due to cold and heat temperatures may obscure the relationship between temperature and specific cardiovascular outcomes. Additionally, there might be methodological limitations. Compared to the meta-analysis, a multilevel model has been used as more efficient and less prone to bias. However, a multilevel model is not always feasible especially in the presence of the complex time series regression models with a high number of parameters to account for confounding factors (Gasparrini and Armstrong, 2011; Gasparrini et al., 2012). Thus, to avoid the specification of a very highly parameterized hierarchical structure in a multilevel model, we used a two-stage analysis, with a prefecture-specific model and then a multivariate meta-regression model to pool the estimates. However, it is worth noting that the Cochran Q test and I^2 index are dependent on the power of the analysis, with the I^2 index increasing and the *p*-value of the test decreasing proportionally to the precision of the estimates (Rucker et al., 2008). Recently, a new method, the *q*-statistic method, has been proposed as an appropriate method for evaluating spatial stratified heterogeneity (Wang et al., 2016). We should bear in mind when evaluating heterogeneity, and further studies are needed to address these issues.

As the registration of OHCAs is mandatory under law and the data collected are believed to be reliable in terms of quality and completeness, we do not consider the present study to be affected by major selection bias. However, several limitations warrant mention. First, we did not control for the potential confounding effects of air pollutants. Although there is evidence of increased mortality or morbidity due to elevated temperatures with no confounding or effect modifications due to air pollutants, such as ozone, fine particulate matter, carbon monoxide, and nitrogen dioxide (Basu et al., 2008; Michelozzi et al., 2009), further investigation into the effects of air pollution and temperature on morbidity is critical. Second, in addition to weather patterns, many other factors require consideration to explain the heterogeneity between prefectures, such as differences in socioeconomic status, population demographics, geographic factors, underlying disease risk, vulnerable subpopulations, physiological acclimatization, and local adaptations. Different regions may be very heterogeneous and further studies should be conducted to adjust these variables as meta-predictors. Third, we evaluated the relationship between temperature and OHCA using a relative temperature scale. Although associations between absolute mean temperature and morbidity are almost unchanged in the sensitivity analysis, the relative relationship between temperature and morbidity may under- or over-estimate the relationship between absolute scale of temperature and morbidity, and the heterogeneity between prefectures may be also vanished. The more precise modeling of these associations will be a critical focus of future studies.

The practical implications of our findings suggest that a better understanding of the relationships between extreme temperatures and OHCA is crucial for public health officials to identify specific factors that affect susceptibility to extreme temperatures and to explore differences in susceptibility in different populations. Our results may help public health officials in predicting and preparing for extreme temperature-related OHCAs in each prefecture, using preventive public health strategies including forewarning medical staff, improving community access to air-conditioned environments, encouraging fluid intake, advising temporary decreases in physical activity, and implementing early-warning weather forecasts and more efficacious EMS programs. Local health departments in each prefecture should consider the regional temperature when planning region-specific policies for OHCA. Furthermore, health care providers need to maintain a high level of services to help those affected by extreme temperatures and support the community. Our findings suggest that clinics, hospitals, and emergency departments may adapt their procedures to meet the added demands such as adding staff, increasing staff rotation, reducing elective services to free-up staff and beds, and treating patients in nontraditional locations during extreme temperature events (Huang et al., 2012; Huang et al., 2013; Knowlton et al., 2009).

In summary, our nationwide registry-based study identified that extreme temperatures are associated with increased risk of OHCA in Japan. Our results suggest that timely prevention strategies might reduce the risk of OHCA during periods of extremely high or low temperature, and public health interventions allowing for several days of protection should be implemented to reduce the risk of OHCA during periods of extremely low temperature.

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Competing interests

The authors have declared that no competing interests exist.

Author contributions

DO made substantial contributions to conception and design, analyzed data and wrote the manuscript. AH was involved in drafting the manuscript and critically revising it for important intellectual content.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.scitotenv.2016.10.045.

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