Association between temperature and maternal stress during pregnancy

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ABSTRACT

Background: Maternal psychological stress during pregnancy has essentially been conceptualized as a teratogen. However, little is known about the effect of temperature on maternal stress during pregnancy. The aim of this study is to investigate the relationship between temperature and maternal stress during pregnancy.
Methods: In 2010, a total of 1931 eligible pregnant women were enrolled across Shanghai from four prenatal-care clinics during their mid-to-late pregnancy. Maternal life-event stress and emotional stress levels during pregnancy were assessed by the "Life Event Scale for Pregnant Women" (LESPW) and "Symptom Checklist-90-Revised Scale" (SCL-90-R), respectively. Exposure to ambient temperature was evaluated based on daily regional average in different moving average and lag days. The generalized estimating equations were used to evaluate the relationship between daily average temperature/temperature difference and maternal stress.
Results: After adjusting for relevant confounders, an U-shaped relationship was observed between daily average temperature and maternal Global-Severity-Index (GSI) of the SCL-90-R. Cumulative exposures to extremely low temperatures (< P5, 1.4–10.5 ℃, lag 0–1 days, 0–2 days and 0–5 days) and extremely high temperatures (≥ P95, 31.2–34.1 ℃, lag 0–1 days and 0–2 days), and acute exposures to extremely low (lag day 0, 1, 2 and 3) and high (lag day 0, 1) temperatures, all induced higher risks of high GSI (the highest tertile), compared to the risk induced by exposed to an optimal temperature range (20–25 ℃) ($P < 0.05$). Increased temperature difference was associated with high maternal GSI ($P < 0.05$). However, non-significant associations were observed between daily average temperatures/temperature differences and maternal log-transferred LESPW scores.
Conclusions: Cumulative and acute exposures to extremely low/high temperatures may both induce emotional stress during pregnancy.

1. Introduction

As climate change proceeds, more intense, frequent, and long-lasting extreme weather events are anticipated. Global attention to climate change-related (especially temperature) health problems has soared (Koh, 2016). The association between temperature and human health has been observed extensively. Temperature has been reported to be associated with increased risks of mortality (Carmona et al., 2016; Lee et al., 2016; Yang et al., 2016), respiratory disease (Carreras et al., 2015; Li et al., 2014), and cardiovascular disease (Dahlquist et al., 2016; Lanzinger et al., 2014; Phung et al., 2016).

In addition to the effects of ambient temperature on human somatic disorders, a few studies have also investigated the association between temperature and psychological health. Episodes of extreme heat may pose a salient risk to the well-being of the mentally ill in Australia (Hansen et al., 2008). Ambient temperature was also reported to be associated with suicide rates (Dixon et al., 2014; Kim et al., 2016; Kim et al., 2011), and mental fatigue (Bakalidou et al., 2014).

Pregnant women are much more vulnerable to heat compared to the general population (Strand et al., 2011). Previous researches demonstrated the impacts of extreme ambient temperature on adverse birth outcomes, including preterm birth, stillbirth, and low birth weight

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(Dadvand et al., 2011; Strand et al., 2012; Strand et al., 2011; Wells and Cole, 2002), congenital heart defects (Agay-Shay et al., 2013), and teratogenesis (Auger et al., 2017; Kilinc et al., 2016), and also reported the season-related pregnancy complications such as preeclampsia and eclampsia (Beltran et al., 2013; Nasiri et al., 2014; Subramaniam, 2007). Excessive maternal stress during pregnancy was a risk factor for adverse fetus development. Maternal stress during pregnancy was reported to be associated with preterm birth, low birth weight (Dole et al., 2003; Nkansah-Amankra et al., 2010), and adverse neurodevelopment outcomes in infants, including cognitive deficits, changes in temperament traits, and intellectual function (Laplante et al., 2004; Lin et al., 2017a; Virgolini et al., 2008; Xu et al., 2015). However, no study to date has focused on the association between temperature and maternal stress during pregnancy.

Previous studies suggested that the prevalence of depression was higher among pregnant women with pregnancy complications than among those without pregnancy complications (Byrn and Penckofer, 2015; Natasha et al., 2015), and temperature was correlated to the development of pregnancy complications (Yackerson et al., 2007). Low temperature and short sunlight duration were also shown to be the two contributing factors for the development of winter depression (Molin et al., 1996). The risks of postpartum depression decreased with the increasing socio-economic levels (Mukherjee et al., 2017). Thus, we wonder whether pregnancy complications, sunlight duration and socio-economic levels could modify the relationship between temperature and maternal stress.

Therefore, in the present study, we aimed to evaluate the association between ambient temperature (daily average temperature and temperature difference) and the levels of maternal stress during pregnancy, and explored whether the association was modified by pregnancy complications, sunlight duration and socio-economic status (SES).

2. Methods

2.1. Study design and recruitment

From February to October 2010, using stratified-cluster sampling, this study recruited 1,931 pregnant women during 28–36 gestational weeks from all districts of Shanghai who regularly visited the International Peace Maternity and Child Health Hospital, Xinhua Hospital, Xinhua Hospital Chongming branch, and the Minhang Maternal and Child Health Hospital for antenatal examinations, covering the central, southern, and northern areas of Shanghai. As described in our previous publications, the variable used for stratification was the district, and the clustering unit was the hospital (the locations of the selected districts and hospitals were showed in the map in Fig. 1) (Li et al., 2017; Lin et al., 2017b). According to the women's maternity medical record kept in prenatal care clinics, pregnant women with "mental disabilities" were excluded from our study (Li et al., 2017). The detailed recruitment method has been published before (Li et al., 2017; Lin et al., 2017b).

After the women had signed the consent form, in-person interviews were conducted to collect the information on the women's social and demographic characteristics (including age, education and occupation, family monthly income, health status, mental disease history, abortion history, pregnancy complications and parity). Maternal life-event stress and emotional stress levels were assessed by the Life Event Scale for Pregnant Women (LESPW) and the Symptom Checklist-90 Revised Scale (SCL-90-R), respectively.

We obtained written informed consent from all participants, and the study protocol was approved by the Medical Ethics Committee of Shanghai Xinhua Hospital affiliated with Shanghai Jiao Tong University School of Medicine.

2.2. Exposure factors

There is a total of 10 weather monitoring sites in Shanghai, including one national benchmark meteorological station and nine regional meteorological stations, and the land area of Shanghai is 6340 square kilometers (the locations of the monitoring stations were showed in the map in Fig. 1). The national benchmark meteorological station is the only station representing Shanghai to participate in the world meteorological data exchange, providing accurate and reliable weather data throughout Shanghai. There were no significant differences in the reported daily average temperatures in 2010 between the national benchmark meteorological station and the nine regional meteorological stations (Supplementary materials, Table S1), and high correlations were observed (Pearson, r values > 0.99, Supplementary materials, Table S2). The weather data in this study were the average levels throughout Shanghai monitored by the national benchmark meteorological station.

Daily average temperature and temperature difference (daily maximum temperature - daily minimum temperature) were both used as the main exposure indicators. Multiple temperature indexes including the 2-day (temperatures on the day before the recruitment day and the previous 1 days), 3-day (temperatures on the day before the recruitment day and the previous 2 days), 6-day (temperatures on the day before the recruitment day and the previous 5 days) and 8-day (temperatures on the day before the recruitment day and the previous 7 days) moving average temperature/temperature difference were calculated for each woman. We estimated the cumulative effects of the daily average temperature/temperature difference on maternal stress using the following moving average lag structures: 0–1 days (2-day moving average temperature/temperature difference), 0–2 days (3-day moving average temperature/temperature difference), 0–5 days (6-day moving average temperature/temperature difference) and 0–7 days (8-day moving average temperature/temperature difference). We also estimated the non-cumulative effects (acute effect with lag time) of daily average temperature/temperature difference on maternal stress using the following moving average lag structures: lag day 0, 1, 2, 3, 4, 5, 6, 7, respectively.

2.3. Outcome measurements

Face-to-face interviews were conducted by trained staff to assess women's life-event stress levels and emotional stress levels during pregnancy, using LESPW and SCL-90-R, respectively.

The SCL-90-R (Schauenburg and Strack, 1999) is a 90-item self-reported inventory designed to measure distress based on recent psychopathology using nine psychiatric symptoms, including somatization, obsessive-compulsive disorder, interpersonal sensitivity, depression, anxiety, hostility, phobic anxiety, paranoid ideation, and psychoticism. Each item is graded on a 5-point scale of distress (1–5). The SCL-90-R has demonstrated good reliability and validity and has been widely used in the Chinese population (Li et al., 2017; Lin et al., 2017b). The Global Severity Index (GSI) is the mean score of all items (90 items) (GSI score=SCL-90-R total score/90), representing the severity of general psychiatric symptoms. A higher GSI indicates a higher level of emotional stress.

The LESPW is a self-reported instrument widely used in China to specially assess the perceived stress of women during pregnancy. The life-event stress is indicated by asking women which of the 53 potentially stressful life events covering family life, work, study, and social relationships has occurred during pregnancy (Su et al., 2015). The LESPW total score is calculated according to the weighted scores for the events, and a higher LESPW total score indicates a higher level of life event stress during pregnancy. The Cronbach's alpha and the test-retest reliability of the LESPW are 0.96 and 0.79, respectively (Zhang, 2005).