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Ambient Temperature Effect on Pregnancy Outcomes: Single Center Experience from Belgrade †

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Abstract: *Background*: Climate change with global warming and frequent summer heatwaves could negatively impact pregnancy outcome; however, this is still not well understood. *Objective*: To assess the association between ambient temperatures of the last 4 weeks of pregnancy with higher risk for preterm stillbirth. *Material and Methods*: Study included all pregnant women with preterm stillbirth (20 to 37 weeks of gestation) treated in the Clinic for Ob/Gyn University Clinical Center of Serbia during a ten-year period (2010 to 2019). We used meteorological data (minimal, mean and maximal temperatures) per year and month for the city of Belgrade which were provided by Republic Hydrometeorological Society of Serbia and are freely available. *Results*: During the study period, 409 stillbirths occurred in our clinic (1.02% of all deliveries). Gestational week of stillbirth ranged from 18 to 33 (mean ± SD = 23.8 ± 2.9). Mean temperatures ranged from −3.3 °C (January 2017) to 27 (July 2012). Rates of stillbirths were similar in spring and summer compared to autumn and winter months (233 vs. 186; $p = 0.317$), as well as if temperatures were <15 °C and ≥15 °C (200 vs. 209, $p = 0.854$). Moreover, there was no trend in stillbirth rates in relation to ambient temperatures of the last 4 weeks of pregnancy ($p = 0.435$). *Conclusion*: Risk for preterm stillbirth was not associated with ambient temperatures of the last 4 weeks of pregnancy.

Keywords: ambient temperature; pregnancy outcome; premature stillbirth

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1. Introduction

Climate change is the long-term change in the average weather patterns that define local, regional, and global climates. Numerous literature data have confirmed that global warming is currently occurring, which might lead to more frequent and intense environmental disasters, such as heatwaves, wildfires and hurricanes [1,2]. This climate change can also have short and long-term effects on human health ranging from dehydration to heatstroke, respiratory diseases, infectious diseases, mental health complications, cardiovascular disease and even death. A changing climate is a key factor in increasing the intensity, duration, and frequency of heatwaves, which can especially be exacerbated for people with chronic diseases, the elderly and young children, newborn babies and pregnant women [3,4].

During pregnancy, women and their fetuses experience a range of tightly regulated physical and psychologic changes. Pregnant women and the fetus in development present a vulnerable group as numerous factors including environmental ones can disturb the fine metabolic balance of pregnancy and cause different complications for the mother and fetus [5,6]. Any environmental perturbations such as heat or air and water pollution during this sensitive period could have both immediate and life-long consequences for both mother

and the child. Some studies showed that adverse pregnancy outcomes especially occur if pregnant women are exposed to heat during the last week of pregnancy. Exposure to heat toward the end of the gestational period can trigger labor soon after. However, research on the health impacts of climate change on pregnancy outcomes is still limited [7,8].

2. Objective

The study aim was to assess the association between ambient temperatures of the last four weeks of pregnancy with the risk for having a preterm stillbirth.

3. Materials and Methods

This retrospective study was performed at the Clinic for Gynecology and Obstetrics University Clinical Center of Serbia, incorporating a period of ten years (2010 to 2019 year). The study included all pregnant women who had delivered a stillbirth child before term, i.e., before the 37th week of gestation in our clinic. Patient data were obtained from medical records (histories of illness and delivery protocols). To prevent the confounding effects of other different pathologies on study findings, all cases with a known reason for stillbirth were excluded (fetal malformations, infections, etc.).

Meteorological parameters regarding minimal, maximal and average daily temperature were obtained from the website of the Republic Hydrometeorological Society of Serbia, where these data are freely available. Temperatures per year and per month for the city of Belgrade during the examined ten-year period were noted. We assessed the impact of the average temperature during the last month of pregnancy with the pregnancy outcome.

Serbia is a country with a mild continental climate. Measurements of the temperature in Belgrade are performed 2 m above ground at the grass field of the main meteorological station. Measurements are performed three times per day (morning, noon, and evening); based on these findings, the minimal, maximal and average daily temperatures are reported.

Obtained data of patients and temperatures were compared and analyzed using methods of descriptive (number, percent, mean, standard deviation–SD) and analytical statistics. Differences and comparisons between groups were tested using the Hi square test and ANOVA. To analyze trends in temperature and stillbirths, a time series analysis was applied. All analyses were performed using SPSS 20 software.

4. Results

During the study period, 409 stillbirths occurred in our clinic (1.02% of all deliveries). Women who had preterm stillbirths were from 17 to 46 years of age (mean $\pm$ SD = 30.93 $\pm$ 5.99 years) and were mostly primiparous (54.5%; $p = 0.001$). There were no significant differences regarding the gender of stillbirth children (males = 51.8%; females = 48.2%; $p = 0.458$). The gestational week of stillbirth ranged from 18 to 33 (mean $\pm$ SD = 23.8 $\pm$ 2.9); at the time of delivery, children weighed 549.30 $\pm$ 214.75 g on average (range 50 to 980 g). We present the rates of stillbirths per month during the examined ten years in Figure 1.

In the examined ten-year period, mean temperatures ranged from -3.3 °C (January 2017) to 27 (July 2012). The coldest month was January every year, while July and August were generally the hottest months ($p = 0.001$). April to September are considered as summer and spring months with an average temperature of $\geq$ 15 °C. The hottest years were 2012, 2013 and 2018, with average yearly temperatures of $\geq$ 15.5 °C. However, there were no significant differences in average yearly temperatures in Belgrade during the examined ten years ($p = 0.738$). The mean temperatures per year in Belgrade, Serbia, between the years 2010 and 2019 are presented in Figure 2.

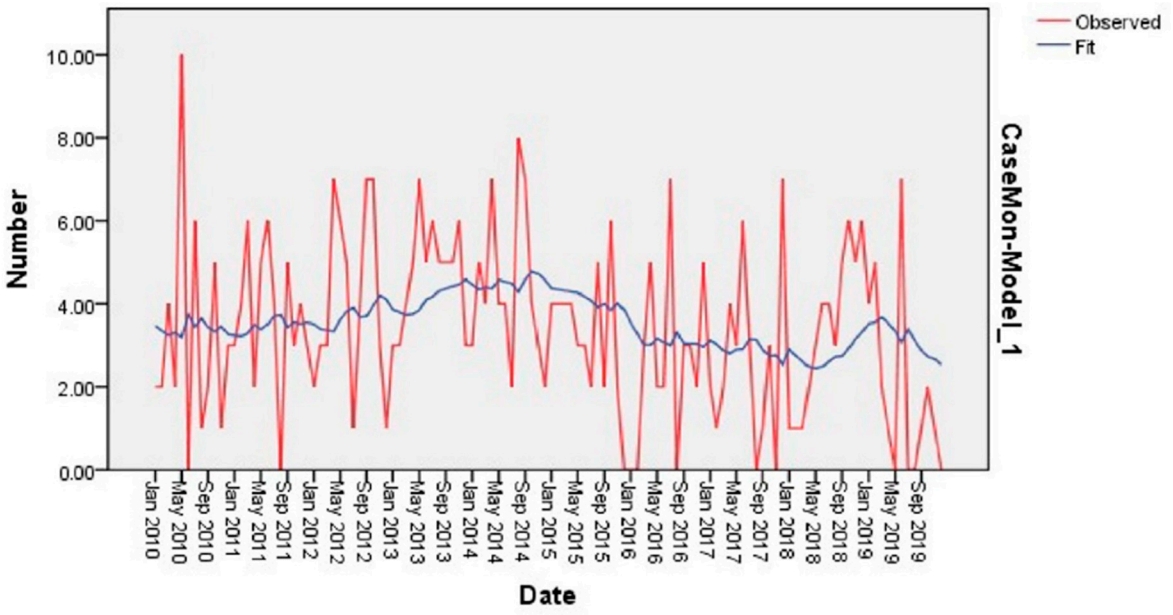

Figure 1. Rates of stillbirths per month during the examined ten years (2010–2019).

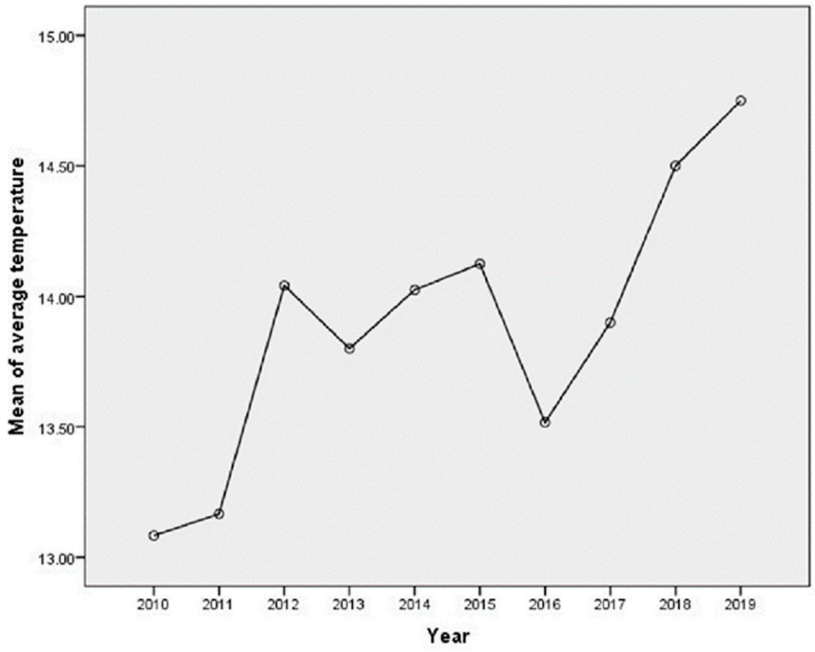

Figure 2. Mean temperatures per year in Belgrade, Serbia between the years 2010 and 2019.

Rates of stillbirths were similar in spring and summer compared to autumn and winter months (233 vs. 186; $p = 0.317$) as well as if temperatures were <15 °C and ≥15 °C (200 vs. 209, $p = 0.854$). Moreover, there was no trend in stillbirth rates in relation to ambient temperatures of the last four weeks of pregnancy ($p = 0.435$).

5. Discussion

Numerous studies undertaken worldwide found that exposure to heat is associated with a higher risk of adverse pregnancy outcomes such as preterm birth, low birthweight, and congenital anomalies—especially of the heart—and stillbirth. Some authors found a correlation between prenatal heat exposure and decreased cognitive ability in later life [5,7]. Maternal health is also at risk with heat exposure, with studies identifying increased incidence of maternal hypertensive disease, gestational diabetes and bleeding

due to placental abruption. No critical period of maternal exposure to heat has yet been definitively identified, but data suggest that heat exposure earlier in a warm season is more harmful than later due to lack of acclimatization [9,10].

Environmental heat can present a health risk for pregnant women by causing an increase in core body temperature. This occurs through a few mechanisms [11,12]. Increased body weight and fat during pregnancy increase core body temperature and heat production. The decreased ratio of surface area to body mass of pregnant women reduces the heat-loss capacity of sweating. Finally, the fetal metabolism also increases maternal body temperature. When environmental temperature exceeds the maternal core body temperature, the physiological reaction is cutaneous vasodilation and sweating along with decreased uterine and umbilical cord blood flow. If heat-loss mechanisms are unable to disperse heat effectively, the body becomes dehydrated which is a hazard for both mother and fetus. In such conditions, the endocrine system activates and releases the antidiuretic hormone and oxytocin, further decreasing uterine blood flow to the fetus which may cause transient asphyxia or even death. The hormonal response to dehydration may even trigger labor regardless of the expected term. In addition, heat exposure can cause acute heat stress. If stress occurs, heat-shock protein is released into maternal circulation. The heat-shock protein is known to damage placental cells and reduce placental efficiency, thereby decreasing adequate oxygen and nutrition supply to the fetus. Consequently, frequent heat shocks during pregnancy can lead to intrauterine growth restriction of the fetus. Moreover, heat stress can interrupt the typical sequence of gene activity, causing congenital anomalies or stillbirths [11,12].

Data from California indicate that the risk of stillbirth increases 10.4% for every 5.6 °C increase in ambient temperature. This risk is even higher for younger and less educated mothers, as well as male fetuses. The highest risks were observed during gestational weeks 20–25 and 31–33 [13]. Authors from Brisbane, Australia, found that risk of stillbirth increased with exposures during the prior week up to temperatures of 21 °C, but that there was no increased risk at the highest temperatures. Still, the peak of stillbirth rates in Australia is during the summer [14]. On the other hand, studies performed in Nordic countries revealed that stillbirth rates did not show a linear trend during the last century, but had a peak in the 1930s, in particular among boys. Trends differed also by region and per year. No clear effect of temperature on stillbirths across the entire year was found in Sweden. However, stillbirth risk was highest in spring and summer, both at low and high temperatures [15,16]. In contrast, some authors found a link between high stillbirth rates and winter and spring months in New York, Minnesota, and Switzerland [13]. We did not find any significant differences in rates of stillbirths throughout the ten-year period regardless of the season.

The delivery of a stillbirth has been shown to occur significantly more often as a response to ambient temperature in a couple of days to up to a week after exposure [7,8]. When we analyzed the impact of average temperature one month before the adverse pregnancy outcome, no correlation was found.

The novelty of our study is the fact that it is the first to examine the link between acute exposure to heat and risk of preterm stillbirth is Serbia. The major study limitation is not testing for other different environmental or gynecological risk factors (use of air conditioning, etc.). Therefore, further research with a greater number of parameters regarding the examined pregnancies as well as environmental factors during longer periods of time is needed to fully understand the mechanisms of interaction between environment and pregnancy health.

6. Conclusions

According to the results of our study, the risk for preterm stillbirth was not associated with ambient temperatures in the last four weeks of pregnancy of women in Serbia.

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