Juri Altaouil

Women's Health Institute
USA

Heat Exposure, Climate Change, and Birth Defects: Population-Based Approach on Female Reproductive Health

Abstract:

Climate change has unfolded as a serious global health concern and threat, with growing evidence linking environmental heat exposure to adverse reproductive outcomes. Maternal exposure to elevated temperatures has been associated with increased risks of stillbirth, low birth weight, preterm birth, and congenital anomalies. A meta-analysis by Lakhoo et al. (2024) found that each 1°C rise above average regional temperatures elevated risks for multiple maternal and neonatal outcomes. Additional data reports heightened vulnerability in underserved populations due to limited access to healthcare, cooling resources, and adaptive infrastructure. For example, structural birth defects, including spina bifida, hypospadias, and congenital heart abnormalities, have been associated with high environmental temperatures, particularly during critical windows of fetal development (Haghighi et al., 2021). The effects are worsened by related climate stressors, including air pollution, vector-borne diseases, and flooding, again, disproportionately affecting low-income and rural communities (Segal & Giudice, 2022; Kaur & Pandey, 2021). Despite this growing evidence, most public health policies and heatwave protocols do not fully address the specific needs of pregnant women. There is an urgent need for climate-informed reproductive healthcare templates, targeted policy interventions, and surveillance systems to reduce preventable birth defects and improve outcomes, especially for at-risk populations. A population-based approach is important to advance reproductive justice in the face of accelerating climate change.

Methods: Expert reviews, systematic reviews, and meta-analyses were examined for the overall qualitative synthesis from peer-reviewed literature. The relationship between climate change-related exposures to women and their adverse reproductive outcomes was investigated. In the search strategy, high-quality reviews from a plethora of education sources like PubMed, Scopus, Web of Science, and Google Scholar were used. All reviews were conducted from 2021-2024 data. Terms like "maternal heat exposure", "climate change", "pregnancy outcomes", "stillbirth", "congenital anomalies", "air pollution", "wildfire smoke", and "fetal development" narrowed the search.

Limitations: This study was restricted to English language publications only. Also, although

the study excluded single-cohort or observational studies, this approach excluded systemic environmental impacts for women.

Discussion: Across numerous systematic reviews, meta-analyses, and expert reviews, evidence has been found that links maternal heat exposure to various reproductive outcomes. It was found that maternal heat exposure increases the risk of stillbirth by 24%, low birth weight by 11%, and preterm birth by 16% (Lakhoo et al., 2024). Each increase in temperature by 1°C increases the risk of those reproductive outcomes as well. These studies span 66 countries and six continents, emphasizing the prominence of the issue. For example, in a systematic review by Haghighi, it was found that exposure to greater than 30°C heat for over 15 days causes more prevalent birth defects. Additional research found that 19 out of 20 studies showed the correlation between heat and stillbirth risk with exposures from 12.64°C to 46.4°C (Bonell et al., 2023). There is a range of congenital anomalies that are observed to be linked with regions experiencing heat waves. Specifically, hypospadias, congenital cataracts, spina bifida, neural tube defects, and craniofacial defects are all linked to heat exposure (Haghighi et al., 2021; Lakhoo et al., 2024). Heat exposure poses the highest risk during the third trimester of pregnancy, causing particularly stillbirth (Bonell et al., 2023). There were still associations with the fifth to tenth weeks of gestation, showing that they are sensitive periods as well, especially for cardiac developmental problems. (Haghighi et al., 2021). Differences in populations were also noticed with an increased risk of craniofacial defects in Hispanic groups exposed to heat versus non-Hispanic groups (Haghighi et al., 2021). Heat exposure triggers mechanisms like reduced placental blood flow, dehydration, congenital malformation, and maternal heat strain (Bonell et al., 2023). This can contribute to birth defects and the development of the fetus. Additionally, in a systematic review by Segal and Giudice, research showed that sperm and oocyte quality were reduced by the elevated temperatures, resulting in a decline in ovarian reserve and birth rates. Whether the heat exposure is short-term or chronic, it still poses a deep risk. Environmental exposures like air pollution consistently show poor outcomes in female reproductive health. Air pollution exposure during pregnancy has correlated with conditions such as asthma, decreased attention and visual memory, and lowered intelligence for children in utero. Even if there is moderate exposure to air pollution, it can still cause changes in the placenta, resulting in nitrosative stress and altered deoxyribonucleic acid (DNA) methylation (Segal and Giudice, 2022). Padula et al., from the systematic review by Papadiochou, found that exposure to airborne polycyclic aromatic hydrocarbons (PAHs), which is commonly found air pollution, during the last six weeks of pregnancy increased the risk of early preterm birth. Children can also have less developed lungs at birth, which are not properly functional until about 6–8 years of age if exposed to air pollution (Kaur and Pandey, 2021). Smoke from wildfires also causes birth defects. Exposure as early as 3 weeks can result in an increased risk of low birth weight. A study done in Colorado found that exposure to particle PM2.5, the principal pollutant of concern from wildfire smoke, was associated with preterm birth during the second trimester (Segal and Giudice, 2022). Due to the heat from climate change, icecaps are melting, which causes flooding in regions. The stress from these events affects pregnant women. For example, women during the 2008 Iowa flood and 2011 Queensland flood had

toddlers with higher stress and delayed motor development at 6 months old (Segal and Giudice, 2022).

Conclusion: The evidence from the literature review supports a link between climate change and adverse reproductive outcomes, such as stillbirth, preterm birth, low birth weight, and congenital anomalies. By addressing reproductive health impacts from climate change, future public health systems and prenatal care guidelines will target women from vulnerable populations. In such communities, women are faced with adversity and have limited access to disproportionate healthcare compared to healthy populations. To effectively mitigate these inequities, a multidisciplinary call to action is needed, specifically one that unites medicine, public health, and climate policy. There remain critical gaps in both social policy and clinical practices that contribute to persistent disparities in maternal health outcomes. Environmental exposures must be addressed not only as scientific and medical concerns but as urgent public health threats requiring systemic intervention. The development of pregnancy-specific heat wave action plans, with clearly defined thresholds for heat-related danger, is one example of a necessary policy response. Moving forward, protecting maternal and neonatal health will require greater investment in climate-informed prenatal care and research that prioritizes environmental justice and fertility equity across all populations. Future work should explore scalable digital health solutions and real-time heat monitoring tools to support pregnant individuals during extreme weather events.

Biography

Juri Altaouil is a Rutgers University graduate with dual Bachelor's degrees in Psychology and Health Administration and a Minor in Biological Sciences. She is a Research Intern at the Women's Health Institute at Rutgers Robert Wood Johnson Medical School, where her work focuses on women's reproductive health, environmental health equity, and the effects of climate change on maternal and neonatal outcomes. Juri is passionate about advancing reproductive justice through interdisciplinary research and public health advocacy.