Review Article

The Effects of Climate Change on Maternal, Fetal and Neonatal Health: An in-Depth Review

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Abstract

The substantial elevation in atmospheric greenhouse gas levels is a consequence of human activities, resulting in a 1.1°C elevation in surface temperature as the worldwide average. The detrimental outcomes of this temperature rise encompass severe weather events, deterioration in food, water, and air quality, alongside an escalation in vector-borne infectious diseases and/or transmission risks. The mitigation and adaptation to climate change are pivotal factors for the survival of humanity in the midst of this existential crisis.

Climate change exerts notable effects on maternal, fetal, and neonatal health, with women experiencing more adverse impacts compared to men. Pregnant women may face conditions such as hypertensive disorders like preeclampsia and eclampsia, gestational diabetes mellitus (GDM), variations in pregnancy duration, and mental health disorders. Fetal and newborn health can be affected, leading to results like preterm birth (<37 weeks of gestation), low birth weight (<2500 grams), congenital anomalies (including atrial septum issues), early membrane rupture (EMR), underdeveloped immune systems, intrauterine growth restriction (IUGR), and neonatal death.

Effective interventions aimed at reducing heat-related risks should include health education on heat and heat increase risks for caregivers - other than parents - and clinicians responsible for childcare. Additionally, there is a need for improvements in cooling systems in healthcare facilities, fair enhancements in housing quality, and food systems. Focus should also be placed on nutrition and lifestyle counseling.

Despite the growing attention to the influence of climate on human health, the risks associated with heat and other factors associated with climate for women, pregnant individuals, newborns, infants, and children are not sufficiently addressed. This review seeks to investigate the effects of climate change on maternal, fetal, and neonatal outcomes related to health based on existing literature.

Keywords: Climate change, fetal health, maternal health, neonatal health.

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Derleme Makale

İklim Değişikliğinin Anne, Fetüs ve Yenidoğan Sağlığı Üzerindeki Etkileri: Kapsamlı Bir İnceleme

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Öz

Atmosferdeki sera gazı seviyelerindeki önemli artış, insan faaliyetlerinin bir sonucudur ve yüzey sıcaklığında dünya ortalamasına göre 1,1°C'lik bir artışa yol açmaktadır. Bu sıcaklık artışının zararlı sonuçları arasında, şiddetli hava olayları, yiyecek, su ve hava kalitesinde bozulma, ayrıca vektör kaynaklı bulaşıcı hastalıklarda ve/veya bulaşma risklerinde artış yer almaktadır. İklim değişikliğinin azaltılması ve iklim değişikliğine uyum, bu varoluşsal krizin ortasında insanlığın hayatta kalması için çok önemli faktörlerdir.

İklim değişikliği anne, fetüs ve yenidoğan sağlığı üzerinde kayda değer etkiler yaratmakta ve kadınlar erkeklere kıyasla daha fazla olumsuz etki yaşamaktadır. Gebe kadınlarda, preeklampsi ve eklampsi gibi hipertansif bozukluklar, gestasyonel diyabet (GDM), gebelik süresindeki değişiklikler ve zihinsel sağlık bozuklukları gibi durumlara neden olabilmektedir. Fetüs ve yenidoğan sağlığı ise erken doğum (<37 gebelik haftası), düşük doğum ağırlığı (<2500 gram), konjenital anomaliler (atriyal septum sorunları dahil), erken membran rüptürü (EMR), az gelişmiş bağışıklık sistemleri, intrauterin büyüme kısıtlaması (IUGR) ve neonatal ölüm.gibi sonuçlara yol açabilmektedir.

Isıya bağlı riskleri azaltmayı amaçlayan etkili müdahaleler, ebeveyn dışındaki bakıcılar ve çocuk bakımından sorumlu klinisyenler için ısı ve ısı artışı riskleri konusu sağlık eğitimi kapsamına alınmalıdır. Ayrıca sağlık tesislerindeki soğutma sistemlerinde iyileştirmelere, konut kalitesinde ve gıda sistemlerinde iyileştirmelere ihtiyaç bulunmaktadır. Ayrıca beslenme ve yaşam tarzı danışmanlığına da odaklanılmalıdır.

İklimin insan sağlığı üzerindeki etkisine artan ilgiye rağmen, kadınlar, hamileler, yeni doğanlar, bebekler ve çocuklar için sıcaklık ve iklimle ilişkili diğer faktörlerle ilişkili risklerin yeterince ele alınmadığı düşünülmektedir. Bu derleme, iklim değişikliğinin sağlıkla ilgili anne, fetus ve yenidoğan sonuçları üzerindeki etkilerini mevcut literatüre dayanarak araştırmayı amaçlamaktadır.

Anahtar Kelimeler: İklim değişikliği, fetus sağlığı, anne sağlığı, yenidoğan sağlığı.

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1. Introduction

Since ancient times, human activities have had an impact on the environment. The rapidly increasing human population has rendered the living space and the environment, susceptible to adverse interactions. However, for human populations to sustain their existence on Earth, favorable climatic conditions are imperative (Sen, 2022). The advancement of technology has given rise to new challenges, surpassing the self-preserving capacity of the natural environment. The period encompassing the Industrial Revolution (1760-1830) has been instrumental in the escalation of greenhouse gas concentrations, notably carbon dioxide (CO_2) and methane (CH_4). Projections indicate that the global mean temperature is anticipated to experience a surge of approximately 3°C by the year 2030 as a consequence of these anthropogenic activities (Telecommunication Branch Directorate, 2008).

One of the greatest risk factors for the global population is climate change. The occurrence of global warming is a direct outcome of the rising levels of greenhouse gases present in the atmosphere. As a result, uncontrollable wildfires, air pollution, ecological changes, and flooding emerge due to the resulting weather conditions. Consequently, these factors precipitate demographic dislocation, familial disintegration, heightened proclivity for conflict, ramifications on the quality and accessibility of water resources, challenges to food stability, implications for public health, and perturbations to economic infrastructures. These effects ultimately limit the ability of citizens to maintain security (Kuehn and McCormick, 2017).

An elevation of approximately 0.5 to 1 °C in the surrounding temperature linked to the phenomenon of global warming constitutes a peril to the viability of diverse biological species, encompassing the human population (Poursafa et al., 2015; Weihua et al., 2015; McMichael and Woodruff, 2006). Within cohorts susceptible to rising temperatures, there typically are young children below the age of five, individuals aged sixty-five and above, those with pre-existing disorders, individuals possessing restricted adaptive capacities to temperature escalation due to socio-economic disadvantages, the female demographic, and pregnant women (Kuehn and McCormick, 2017; Harlan et al., Halonen et al., 2011).

The imperative underscored by the World Meteorological Organization and the World Health Organization (WHO) accentuates the necessity of incorporating heat exposure considerations into both clinical healthcare practices and public health initiatives (Kuehn and McCormick, 2017; Molina and Saldarriaga, 2016). Elevated temperatures have detrimental effects on the human physiological system, compromising mechanisms of heat dissipation and thermoregulation. Consequently, this disruption manifests as heat exhaustion and heatstroke, denoted by a condition featuring a core temperature equal to or exceeding 40.6 °C, accompanied by dysfunction in the central nervous system (Bouchama and Knochel, 2002).

Climate change impacts the health and general well-being of individuals through a set of both direct and indirect consequences. Direct ramifications involve the elevation of ambient temperatures and the contamination of the atmosphere, while indirect consequences encompass the exacerbation of water scarcity, heightened frequency of flooding incidents, proliferation of infectious diseases, escalated susceptibility to contagion, and the progression of desertification (Donmez Ozturk and Kurt, 2023). Owing to these impacts, the determinants of human health, both social and environmental, are detrimentally influenced.

Cianconi et al. (2020) systematically reviewed the literature available up until the end of June 2019 from PubMed, EMBASE, and the Cochrane Library. A total of 445 articles and association reports were identified, and from these, 163 articles and association reports were selected based on predetermined inclusion criteria. A thorough investigation was carried out to examine the interrelation between climate change, occurrences of weather events of extreme nature, and the prevalence of mental health disorders. This investigation delved into conditions including depression, anxiety, schizophrenia, and mood disorders, as well as their potential correlation with suicide, aggressive behaviors, and the psychological distress induced by the loss of familiar landscapes. The research outcomes revealed the diverse form of the impact of climate change, ranging from direct to indirect effects, and varying in duration from short-term to long-term consequences. Acute incidents, akin to traumatic stress, were identified as potential triggers for well-recognized psychopathological patterns. Furthermore, the aftermath of prolonged exposure to extreme weather events may exhibit delayed effects, giving rise to conditions such as post-traumatic stress (PTS), with a significant likelihood of the intergenerational propagation of these effects to successive cohorts (Cianconi et al., 2020).

Climate change disproportionately affects disadvantaged communities, including those with low incomes and different ethnic backgrounds, due to the unequal distribution of resources and socioeconomic conditions when disasters occur. Africa is among the continents that are heavily impacted by climate change (IPCC: Summary for Policymakers, 2021). African nations, including but not limited to Nigeria, Kenya, and Ghana, are presently confronted with a substantial burden of deaths in newborns. The number of preterm births and low birth weight surpass those observed in other continents, and a considerable number of pregnant women encounter health challenges throughout the gestation period (Nakstad et al., 2022). Within the United States, fatalities resulting from extreme heat events surpass the cumulative death toll attributed to all other weather-related occurrences (National Oceanic and Atmospheric Administration, 2024). In India, it is predicted that average annual temperatures will increase by 1.7 to 2.2°C by 2030 compared to the 1970s. A simultaneous rise in the duration and severity of heatwaves is also anticipated (Barros et al., 2014). Consequences in relation to health are already apparent, reflected in the increasing number of fatalities associated with elevated temperatures for the last 15 years (Azhar et al., 2014; Akhtar, 2007; McMichael et al., 2008). Despite surveillance data gaps, several studies suggest that women, especially those who are pregnant or older, experience a higher threat of health outcomes related to heat (Kovats and Hajat, 2008; Schifano et al., 2009).

Climate change constitutes a significant risk in comprehensive health outcomes, including people's overall well-being, as well as their reproductive health. The climate crisis adversely affects the risk dynamics related to women's sexual health, reproductive well-being, and rights, as well as the health of newborns and children. This review seeks to explore the impacts of climate change on maternal, fetal, and neonatal health in the context of the existing literature.

1.1. Effects of Climate Change on Maternal, Fetal, and Neonatal Health

The utilization of fossil-based energy in human activities results in the emission of greenhouse gases, including methane (CH_4) and carbon dioxide (CO_2), into the Earth's atmosphere. The release of these greenhouse gases causes alterations in the chemical composition of the troposphere, thereby contributing to climate change and variability (Sen, 2022).

The health consequences of climate change, regardless of the mother's ethnicity or age, include hypertensive disorders such as preeclampsia and eclampsia, gestational diabetes mellitus (GDM), duration of pregnancy, and mental health disorders. Younger mothers face a higher threat of experiencing these unfavorable consequences (Balbus and Malina, 2009; Basu et al., 2016; Ha et al., 2017; Kuehn and McCormick, 2017; Rylander et al., 2011; Strand et al., 2011; Van Zutphen et al., 2012;). Health outcomes in the fetus or the newborn include preterm birth (before the 37th gestational week), low birth weight (less than 2500 g), congenital anomalies, early membrane rupture (EMR), compromised immune system development, intrauterine growth restriction (IUGR), and neonatal mortality (Donmez Ozturk and Kurt, 2023; Guidice et al., 2021; Poursafa et al., 2015).

Poursafa and colleagues (2015) conducted a systematic review that revealed significant correlations between parameters associated with climate change and outcomes during pregnancy, including preterm birth, preeclampsia, eclampsia, congenital anomalies, low birth weight, newborn gender ratio, and gestational age (Poursafa et al., 2015). The literature review additionally identified a significant correlation between variations in ambient temperature values through the course of pregnancy and the occurrence of gestational diabetes mellitus (Booth et al., 2017; Robledo et al., 2015; Schifano et al., 2016; Verburg et al., 2016).

Veenema and her colleagues (2023) conducted a comprehensive systematic review by exploring the databases of PubMed and Web of Science. The examination of 19 articles unveiled that both extremely high and low temperatures exert adverse effects on the health of newborns and mothers. The review established a noteworthy correlation between exposure to air pollution and unfavorable pregnancy consequences, further associating unwanted pregnancy outcomes with hurricanes, tropical storms, and sudden floods. The systematic review emphasized the significant correlation between environmental exposure associated with climate change, including extreme temperatures, atmospheric pollution, and natural disasters, and the prevalence of unwanted outcomes in perinatal and maternal health in the United States.

1.2. Effects of Climate Change on Maternal Health: A Comprehensive Examination

The human body maintains an internal temperature of approximately 37 °C (±1 °C) through the regulatory mechanism of homeostasis (Ziskin and Morrissey, 2011). Within certain limits, individuals can endure inside temperatures lower than 35°C or exceeding 41°C for a specified time. In conditions where the external temperature exceeds the skin temperature, leading to a reversed thermal gradient from the skin to the air, the body can absorb heat from its surroundings through three mechanisms, which are radiation, convection, and conduction. Consequently, exposure to elevated environmental temperatures prompts the body to counteract the deviation from a theoretical "set point" in internal temperature. This regulatory response involves mechanisms of cooling, like increased blood flow toward the skin and heightened perspiration. Conversely, when there are temperatures lower than the optimum level, the body initiates opposing measures, including reduced blood flow toward the skin and processes such as shivering to generate heat. In ordinary physiologic circumstances, the optimum point remains somewhat stable and resistant to heat influences (International Labour Office, 1998).

Individuals and ethnic groups display variability in their acclimatization to heat, primarily influenced by distinctive characteristics affecting the transmission of heat, including the body mass index (BMI), surface area, physical attributes, and thickness of insulating skin fat layers. Elevated ambient temperatures can lead to physiological complications, notably

heatstroke, heat syncope, heat cramps, heat edema, and heat exhaustion, where, heat cramps, heatstroke, and heat exhaustion are clinically significant conditions. Throughout these processes, both systemic and local disruptions manifest. The fundamental mechanisms contributing to systemic problems involve insufficient circulatory processes, imbalances in levels of water and electrolytes, and/or hyperthermia. Concurrently, local problems like skin lesions may also ensue (International Labour Office, 1998).

The United Nations Framework Convention on Climate Change acknowledges that women face elevated risks and bear a disproportionate burden of the consequences arising from climate change. This issue is specifically clear in the realm of health impacts, accentuating climate change as an exacerbating factor for gender-based health disparities (Intergovernmental Panel on Climate Change, 2014). Both the World Health Organization (WHO) and the American College of Obstetricians and Gynecologists (ACOG) assert that women face increased vulnerabilities due to a confluence of biological, political, and cultural factors (ACOG, 2016; Chauhan and Kumar, 2016; WHO, 2014). Although it is not the direct subject of the study, it should be noted that approximately 1.3 billion people worldwide live below the poverty line, and 70% of this population, especially in low- and middle-income countries, are women (WHO, 2002).

The health-related ramifications of the phenomenon of climate change exhibit gender-specific disparities, influenced by underlying socio-economic, cultural, and physiological factors. Typically, women tend to endure more pronounced adverse effects compared to men (Guidice et al., 2021; Sorensen et al., 2018). This is because women have physiological differences from men in terms of their biological vulnerabilities to high temperatures. Women demonstrate a lower capacity for heat dissipation through perspiration, exhibit a heightened working metabolic rate, and possess a thicker subcutaneous fat layer, all contributing to a diminished capacity for radiant cooling (Duncan, 2006). Additionally, pregnancy introduces vulnerability, as the physiological and anatomical changes during pregnancy reduce thermoregulatory capacity. These changes, driven by increased metabolism and internal heat production due to fetal growth, result in alterations in body mass index with increased fat accumulation (Bekkar et al., 2020). Although direct causation of adverse pregnancy outcomes may not result from maternal exposure to the external environment, it is essential to examine potential impact mechanisms via genetic, epigenetic, socio-demographic, and other recognized forms of predisposition (Asomoah et al., 2018).

Desai and Zhang (2021) conducted a comprehensive scoping review to unravel the intricate association of climate change with the health of women. The findings underscore that climate change poses a significant hazard regarding global public health, especially amplifying existing gender inequalities. The review primarily focused on countries with low and medium levels of income in the existing literature. Four overarching themes emerged, covering the susceptibility of women to the risk of influence of climate change, its resulting effects on the health of women, variables associated with predisposition and vulnerability, and suggested intervention tactics to mitigate the effects of climate change. Notably, the review highlights the heightened susceptibility of women's health to climate change, particularly in countries in the low- and middle-income categories. Emphasizing the inclusion of women's perspectives in the development of adjustment and mitigation strategies is crucial for enhancing resilience. Additionally, the use of mixed methods is strongly advocated to facilitate policymaking in line with evidence in the field of climate change interventions.

The climate exerts direct influences on the health of diverse populations globally, encompassing the well-being of mothers, fetuses, and newborns (Crimmins et al., 2016; Blencowe et al., 2012). Heat is possibly the most significant concerning health outcome associated with climate (Haines et al., 2006). In their systematic review, Kuehn and McCormick (2017) aimed to analyze current literature examining the consequences of the global increase in temperatures and extreme heat on pregnancy outcomes. The search for articles detailing exposures related to climate change and adverse health effects for pregnant women involved querying the PubMed and Cochrane databases. The review's findings indicate a higher occurrence of preterm births, a decrease in birth weight, and a possible increase in the numbers of stillbirths due to the global rise in temperatures and extreme heat. Additionally, the results suggest that newborns may face increased vulnerability to heat-related health issues and mortality. However, further research is needed to fully understand these associations. The study emphasizes the critical need for ongoing public health efforts to address the localized effects of climate change.

While this research actively explores the influence of climate change on health in the physical sense, research examining its effects on mental health is comparatively less advanced. Furthermore, the specific interest in investigating the mental health effects of climate change on women should be noted. The aforementioned interest arises from the acknowledgment of the potentially disproportionate negative experiences that women may face in connection with climate change and associated events.

The primary objective of the scoping review undertaken by Stone and colleagues (2022) is to scrutinize the current body of literature pertaining to the influence of the phenomenon of climate change on the mental health of women. A comprehensive search of relevant publications through databases discussing the mental health of women and climate change yielded twenty studies meeting the inclusion criteria for the review. The study underscores the explicit need for climate policies that address both adaptation and mitigation issues, considering the unique needs of women to safeguard their health and well-being (Stone et al., 2022).

1.3. Impact of Climate Change on Fetal and Neonatal Well-being: A Comprehensive Examination

Newborns and infants exhibit diminished capacity for heat dissipation and regulation (Smith, 2019) and are 4.4 times more vulnerable to heat-related mortality compared to young adults (Berko et al., 2014). Elevated temperatures trigger various pathophysiological mechanisms that are seen in the form of clinical signs in both the fetus and the newborn. Among these signs are elevated fetal heart rate (tachycardia), decreased fetal movements, and signs of fetal distress. Clinical signs of heat stress in newborns may include meconium aspiration, dehydration, neonatal hyperbilirubinemia, heat exhaustion, and neurological dysfunction (Cil and Cameron, 2017; Scrafford et al., 2013; Cheng and Partridge, 1993). Prolonged exposure to heat can also lead to long-term sequelae or even death.

A research endeavor led by Mannan and colleagues (2011) in rural Bangladesh found that infants delivered at home during excessively hot periods exhibited a significantly higher likelihood of developing serious illnesses compared with those born on cooler days (Mannan et al., 2011).

The thermoregulatory capacity of a newborn is dependent on various parameters such as the ambient temperature, nutrition, time of day, age, and rate of growth (Sahni, 2021). In elevated ambient temperatures, maintaining neonatal thermal balance is not solely

achieved by reducing the basal metabolic rate; rather, it necessitates vasodilation and further dissipation of heat via the evaporation of sweat.

In premature infants, the thermoregulation system can be more delicate due to the larger surface area relative to body weight. During periods of excessive heat, even slight body temperature variations can increase the probability of deaths in newborns (Molgat-Seon et al., 2023).

Heat has teratogenic effects during critical phases of fetal development (Van Zutphen et al., 2012). Additionally, it enhances the production of vasoactive substances and elevates the viscosity of the blood, influencing the functions of endothelial cells. This alteration can disrupt placental blood flow, potentially culminating in hypertensive crises and an augmented susceptibility to stillbirth (Ha et al., 2017).

Nevertheless, the consequences of fetal exposure to heat during intrauterine development have not yet been clearly understood. The epidemiology underlying various adverse fetal consequences, such as preterm birth (gestational age <37 weeks), shows variability (Blencowe et al., 2012). The hypothesis posits that prolonged exposure to heat and maternal heat stress is a contributing factor to low birth weight (Azhar et al., 2014). While there is no definitive evidence at this point, it is thought that there may be a connection between extreme deviations in ambient temperature and adverse birth events.

Auger et al. (2017) performed a research in Canada to explore the relationship between outdoor temperatures during the initial three months of gestation and the likelihood of congenital heart defects. The retrospective cohort study included the data of 704,209 fetuses during the 2 to 8 weeks following pregnancy. The rate of congenital heart defects at birth was assessed by considering the number of days on which women were exposed to a maximum temperature of ≥30°C. The study's results indicated that being exposed to excessive heat during the first trimester, particularly affecting the atrial septum, could be related to non-critical heart defects.

Due to physiological, developmental, behavioral, and social parameters, children display a disproportionate vulnerability to the effects of climate change. Moreover, the consequences of these effects have the potential to last through their lives. Midwives and caregivers have a crucial role in assisting families to minimize and adjust to the risks associated with climate change by providing relief and implementing adjustment strategies (Leffers, 2022).

Hellden and colleagues (2021) performed a scoping review, examining the literature on the effects of climate change on pediatric health in the period of January 2000-June 2019. Among 2,970 initially identified articles, reviews, and documents, 371 were subjected to analysis. The investigation, employing an expanded framework, unveiled that the impacts of climate change on the health of children go beyond the determinants in the context of pediatric health, influencing various diseases and mortality rates both directly and indirectly. This comprehensive analysis underscores the far-reaching implications of climate change on child health, impacting not only the determinants but also a spectrum of diseases and mortality rates (Hellden et al., 2021).

The literature reviews suggest that climate change affects the sex ratio of newborns (Helle et al., 2021; Oyejipo et al., 2017). It is postulated that sperm carrying the Y chromosome may be more sensitive to temperature increases due to their more delicate structure compared to sperm carrying the X chromosome (Oyejipo et al., 2017). Helle et al. (2009) investigated the simultaneous influence of economic development levels, wars, famines,

ambient temperature, and total rates of mortality on the yearly variations in the sex ratios of infants. The research aimed to ascertain if such changes were associated with gender-specific infant mortality rates in Finland. The results disclosed an elevation in the male birth ratio during the Second World War and warmer years.

2. Conclusion and Recommendations

Climate change, an existential crisis for humanity, leads to increased temperatures, irregular precipitation causing droughts and floods, a rise in infectious diseases and/or the risk of transmission, and air pollution. Climate change is an immutable condition; however, adaptation to this change is necessary. Midwives should effectively utilize their existing roles as educators, advocates, change agents, leaders, caregivers, and monitors to enhance community and individual resilience, develop coping strategies and future-oriented behaviors, and advocate for policies promoting social support and green environments.

Climate change disproportionately affects vulnerable and unprotected populations, such as mothers, fetuses, and newborns. The climate crisis jeopardizes the fundamental right of every child to be healthy and live well. Action plans addressing climate change must be devised to ensure the health and survival of this vulnerable group. The needs of mothers, fetuses, and newborns should be incorporated into climate change intervention plans. Midwives have a significant role in advocating for strategies to mitigate the effects of climate change, raising awareness, and planning education to safeguard reproductive health for future generations.

Further research is needed on the effects of climate change on mothers, fetuses, and newborns. Understanding and researching potential health issues due to climate change are crucial for maintaining health. Additionally, taking preventive measures regarding potential diseases can reduce complications in pregnant women and fetuses. This compilation identifies some gaps in the literature and provides recommendations for future research. Midwives, who also play a role as researchers, are recommended to conduct studies on the effects of climate change on mothers, fetuses, and newborns.

Author Contributions

This compilation has been planned and authored by Ozten I. and Caglayan Keles N.

Ethical Conflict

The involved parties affirm the absence of any conflicts of interest.

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