NCPD 2.0 ANCC Contact Hours

Abstract
Climate and environmental changes have been described as the biggest global health threat of the 21st century, with the potential to cause immediate harm in early life with important lifelong effects, and important consequences for future generations. Pregnant women and children are increasingly being recognized as vulnerable populations in the context of climate change. The effects can be direct or indirect through heat stress, extreme weather events, and air pollution, potentially affecting both the immediate and long-term health of pregnant women and newborns through a broad range of mechanisms. Climate and environmental changes have wide-ranging effects on a woman's reproductive life including sexual maturation and fertility, pregnancy outcomes, lactation, breastfeeding, and menopause. A comprehensive overview of these impacts is presented as well as opportunities for interventions for nurses practicing in perinatal, neonatal, midwifery, and pediatric specialties.

Key words: Climate change; Environmental health; Extreme weather; Maternal stress; Perinatal health; Pregnancy health.

CLIMATE AND ENVIRONMENTAL CHANGE: A GENERATION AT RISK

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The Impact of Climate Change on Women and Children

Climate and environmental changes have been described as the biggest global health threat of the 21st century (World Health Organization, 2021). An unprecedented joint statement by the editors of 220 leading nursing, public health, and medical journals worldwide urgently called on world leaders to cut heat-trapping emissions to avoid irreversible "catastrophic harm" (Atwoli et al., 2021). Human-induced climate change is causing more frequent and extreme weather events far beyond natural climate variability (Intergovernmental Panel on Climate Change, 2022). Climate and environmental changes pose ongoing and serious risks to women, pregnant mothers, unborn fetuses, and offspring who were exposed in utero to environmental stressors (Roos et al., 2021). Thus, adverse effects can reverberate through the human lifespan as the result of fetal programming and transgenerational inheritance. Children who enter the world disadvantaged from climate-related in utero insults, are predisposed to disease (e.g., congenital defects, neurodevelopmental and psychological impairments, metabolic disorders, obesity, and allergies), and are at higher risk from further climate insults during their own lifetimes (Giudice et al., 2021). We cover a broad overview of climate change effects on maternal child health as well as clinical implications for nurses practicing in perinatal, neonatal, midwifery, and pediatric specialties.

The National Intelligence Council (2021) anticipates that climate change will increase mortality and morbidity associated with more intense storms, flooding, sea level rise, wildfires, heat waves, air pollution, food- and water-borne diseases, vector-borne diseases, and undernutrition due to diminished food production and decreased quality and accessibility of micronutrient-rich food (see Figure 1). Climate change contributes to higher levels of chemical toxicants in the environment. Extreme weather events frequently result in concentrated release of chemicals that can thwart physiologic adaptation to climate change and increase vulnerability to adverse health outcomes (Giudice et al., 2021). Climate change results in significant economic impacts. In the United States, just 20 weather- and climate-related disasters in 2021, including hurricanes, tornados, wildfires, claimed 688 lives and totaled $145 billion (National Oceanic and Atmospheric Administration, 2023). Floods and droughts could cost the global economy $5.6 trillion by 2050 (Aquanomics, 2022).

Vulnerability

Pregnant women and children are recognized as particularly vulnerable populations in the context of climate change. Climate and environmental changes have a disproportionate impact on the health of women and children globally, further exacerbating existing health inequities (Anderko et al., 2020).

In both high- and low-income countries, an estimated 90% of the burden of disease attributable to climate change will be borne by children under 5 years old (Pacheco, 2020). The health effects on women's reproductive lives include sexual maturation and fertility, pregnancy outcomes, lactation, and menopause (Girardi & Bremer, 2022).

Direct and Indirect Mechanisms Affecting Maternal Child Health

Climate change can influence maternal and perinatal health directly or indirectly. The direct and indirect effects frequently occur simultaneously and have an additive impact on pregnancy health. Whether directly or indirectly, climate change can have intrauterine effects, for example, malnutrition, exposure to chemical toxins, and toxic stress before birth are not "forgotten" (Harvard University Center on the Developing Child, 2022). As the fetus develops, its DNA accumulates chemical marks that determine gene expression. This constellation of chemical marks is termed the *epigenome*. The epigenome is affected by environmental toxins and stressful life circumstances which may be incorporated into the architecture of the developing brain with long-term consequences. Epigenetic changes can affect multiple organ systems and increase the risk for poor physical and mental health outcomes and impairments in future learning capacity and behavior (Harvard University Center on the Developing Child, 2022).

Direct Mechanisms

Direct effects are related to the physiologic impacts of temperature, either heat or cold, and organismal and cellular responses to water contamination, pollution, or disrupted services. Direct effects are exerted through extreme heat and weather events (e.g., excessive high temperatures, hurricanes, floods, droughts, and wildfires) which potentially affect the immediate and long-term health of pregnant women and newborns (Helldén et al., 2021).

Extreme Heat

Robust evidence is emerging that extreme heat can result in adverse outcomes including preterm birth, low birthweight, and stillbirth (Bekkar et al., 2020). In the last 100 years, the average temperature of the Earth has increased by 1.2 °C (2.2 °F) with the 6 warmest years recorded in the United States occurring since 2012 (National Oceanic and Atmospheric Administration, 2022). In utero, heat exposure has also been associated with increased risk for fetal congenital anomalies including cataracts and heart defects (Van Zutphen et al., 2012; Zhang et al., 2019).

Pregnant women and children are increasingly being recognized as vulnerable populations in the context of climate change.

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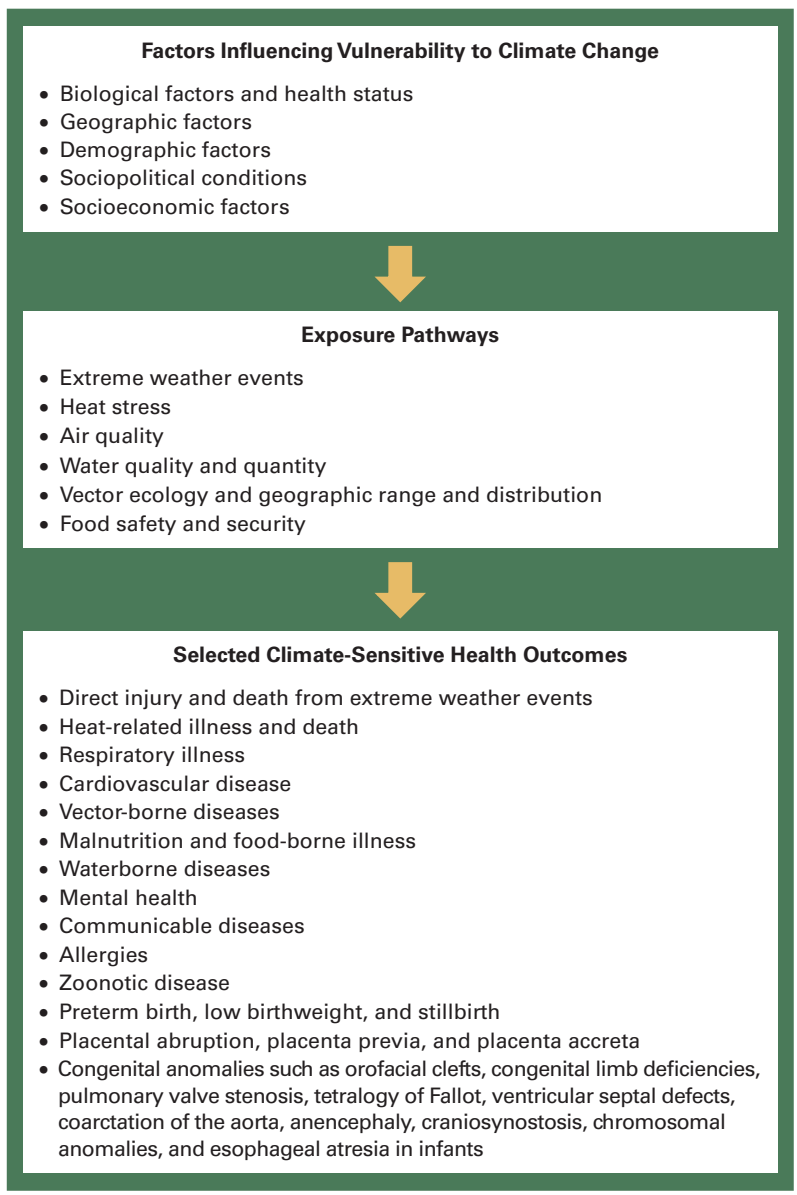
Heat exposure can also compromise maternal health with increased incidence of placental abruption and hypertensive disease (He et al., 2018; Kim et al., 2019). Exposure to high temperatures is of particular concern to maternal child health because pregnancy and neonatal periods are distinguished by both anatomical and physiologic changes which hamper thermoregulation (Samuels et al., 2022). Due to fetal growth, increased fat deposition with attendant changes in body surface to body mass, metabolism, and heat production are significantly augmented in the pregnant woman. When the body is not able to maintain heat balance, heat stress precipitates the release of heat shock proteins. This reaction can provoke a series of physiologic and biological reactions with deleterious effects on maternal and perinatal health including the neonatal period and beyond. Dehydration associated with overheating is significant in pregnancy because of its association with a decrease in amniotic fluid, and may play a role in fetal death (Roos et al., 2021). Temperature-sensitive proteins may contribute to vasodilation within the placenta, consequently lowering blood pressure and therefore blood supply to the fetus (Kuehn & McCormick, 2017).

Air Pollution

There are numerous negative maternal and fetal health outcomes attributed to exposure to ambient air pollution, which can be worsened by climate change (Giudice et al., 2021). Air pollution is linked to placenta-mediated complications, such as placental abruption, placenta previa, and placenta accreta (Michikawa et al., 2016). Umbilical cord insertion anomalies are associated with maternal exposure to air pollution (Michikawa et al., 2022). Other complications that can occur in the pregnant mother include hypertensive disorders of pregnancy, gestational diabetes, and alterations in maternal thyroid functioning (Qiu et al., 2022; Sun et al., 2020; Tang et al., 2020). Fine particulate matter exposure in polluted air can cause mental distress and depression during and after pregnancy (Li, Huang, et al., 2021; Sheffield et al., 2018).

Prenatal exposure to air pollution in all trimesters of pregnancy is a risk factor for low birthweight, fetal growth restriction, preterm birth, and stillbirth (Li et al., 2020; Rappazzo et al., 2021; Xie et al., 2021). Air pollution exposure may be associated with risk of congenital anomalies such as orofacial clefts, congenital limb deficiencies, pulmonary valve stenosis, tetralogy of Fallot, ventricular septal defects, coarctation of the aorta, anencephaly, craniosynostosis, chromosomal anomalies, and esophageal atresia in infants (Ravindra et al., 2021). Immune system functioning in children exposed to air pollution may also become compromised, as evidenced by increased rates of eczema, allergic rhinitis, asthma, pneumonia, otitis media, and childhood cancers (Deng et al., 2016; Johnson et al., 2021; Ravindra et al., 2021).

FIGURE 1. AN OVERVIEW OF CLIMATE-SENSITIVE HEALTH RISKS TO MATERNAL CHILD HEALTH, FACTORS INFLUENCING VULNERABILITY, EXPOSURE PATHWAYS, AND SELECTED CLIMATE SENSITIVE OUTCOMES. CLIMATE CHANGE AFFECTS HEALTH BOTH DIRECTLY AND INDIRECTLY, AND IS STRONGLY MEDIATED BY ENVIRONMENTAL, SOCIAL, AND PUBLIC HEALTH DETERMINANTS.

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Extreme heat and air pollution can result in adverse outcomes including placental abruption, preterm birth, low birthweight, and stillbirth.

Air pollution may be associated with neuroendocrine complications, development of Type I diabetes mellitus, high blood pressure, obesity, congenital hypothyroidism, and insulin resistance in offspring (Heo & Kim, 2021; Shang et al., 2019; Zhang et al., 2018). Air pollution may affect central nervous system development of the developing fetus, decreased inhibitory control in school-aged children, and development of *attention-deficit hyperactivity disorder* and autism (Dutheil et al., 2021; Guxens et al., 2018; Zhang et al., 2022).

Indirect Mechanisms

Indirect effects of climate change can impact women through a wide range of mechanisms with significant health, social, and economic consequences. Extreme weather including floods and drought may result in crop loss, livestock deaths, wildfires, malnutrition, infrastructure damage, shortage of safe water leading to diarrheal disease, interruption of maternal child health services, civil conflict, and migration due to depleted resources like water and arable land. Such events increase women's risk for disease, sexual violence, lack of reproductive control, adverse obstetric outcomes, and death (Helldén et al., 2021).

Reproductive Health

Climate and environmental changes indirectly affect sexual maturation, fertility, lactation, and menopause (Avakian, 2021). Extreme weather events like hurricanes, tornadoes, and floods can result in industrial tank ruptures with resulting chemical spills, or release and transfer of previously contaminated soil. Wildfire and extreme heat events can result in the aerosolization of chemicals and transfer and contamination of food and water sources. Exposure to widely used endocrine disrupting chemicals, including phthalates released into the environment during extreme weather events can alter the physiologic function of the female reproductive system through endocrine blocking chemical effects on the endocrine system. These chemical exposures have been linked to infertility, complications of or pregnancy loss, and increased risk for the development of female reproductive cancers during menopause (Jiang et al., 2021). Exposure to phthalates, parabens, and phenols in utero is also influential in pubertal timing in females (Harley et al., 2019).

A Barrier to Health Maintenance and Promotion

Food insecurities resulting from extreme weather, such as droughts and floods, may have a negative effect on nutrition, thus affecting menstruation (Avakian, 2021). Lack of access to menstrual products, menstrual education, and proper sanitation during and after extreme weather events also creates a barrier to adequate hygiene.

Fecundity, the physiologic potential to bear children, is influenced by many factors including genetics, biological development, nutrition, environment, and social determinants of health. Climate change can influence a woman's fecundity directly through the physical environment, for example, PM2.5 air pollution which is linked to decreased fecundity because of endocrine disruption, oxidative stress, and inflammation (Li, Zheng, et al., 2021). Alternately, climate change may exert indirect influences through interruptions in access adequate nutrition with the potential to adversely affect children's mental and brain development, leading to lifelong gaps on achievement.

In the context of climate change, women who are breastfeeding share similar vulnerabilities to pregnant women (Zadkovic et al., 2021). Food insecurities and unsafe water supplies contribute to the need for exclusive breastfeeding. There is no recommendation to stop breastfeeding. Benefits of exclusive breastfeeding far outweigh any concerns. The influence of climate change on scarce resources in some low-income countries results in displacement, income loss, and power losses which increase disease rate and death. Low breastfeeding rates in high-risk countries influenced by climate change contribute to the negative outcomes, for example, preventable child deaths, diarrhea, and pneumonia in low- and middle-income countries. Infant formula requires mass production by the dairy industry and the plastic and other waste contributes to climate change because of resulting degradation of land and waterways.

Climate change may continue to affect women past childbearing years. There is a dearth of research on effects of climate change on menopause. However, climate change could create a greater burden of menopause symptoms, such as hot flashes and night sweats. Exposure to prolonged temperature increases and extreme temperatures may have a profound impact on quality of life for menopausal women including sleep disturbances, fatigue, and increasing dependence on health care resources (Smith et al., 2020).

Clinical Implications

Nurses practicing in perinatal, neonatal, midwifery, and pediatric specialties care for a uniquely vulnerable population, and through preconception planning, direct education, and public health messaging can have a significant influence on how patients and their communities understand climate change. Helping patients to understand the health harms of climate change, how to minimize its effects, mitigate immediate risk, and adapt to a changing climate can have long-term benefits and help to lessen the harm to future generations. Pregnant women should be counseled to be alert to air quality index information. Air quality index, available at Air Now (2022) provides important information about air quality, associated health effects, and how best to limit exposure. To avoid overheating, women should be educated about the importance of hydration, limiting caffeine, avoiding prolonged exercise, wearing loose clothing, limiting exposure to extreme heat, and appropriate actions to take during a heat advisory. Given the increasing number of natural disasters resulting from climate change, it is imperative that women in areas prone to disasters like hurricanes and wildfires are prepared for an emergency. Although preparations will vary according to the potential emergency, a family action plan, planning for continued care, and an emergency kit are central to optimizing outcomes. Guidance for natural disaster safety for expecting and new parents can be found at the Centers for Disease Control and Prevention (2022) website.

In the event of a natural disaster or other public health emergency, clean drinking water may be unavailable, and the nurse can provide important support for the breastfeeding mother. Formula may become contaminated if prepared with tainted water or stored in nonsterilized containers, or if refrigeration is not available for storage. Therefore, human milk provides the safest food for an infant. Additional benefits of human milk include strengthening the infant's immune system and the hormone release during breastfeeding that helps to mitigate maternal stress.

Nurses should consider the carbon footprint of the care they provide. Currently, the United States' health care system, whose mission is protecting and promoting health, emits almost 5% of the world's greenhouse gasses (Health Care Without Harm, 2022). Nurses can work to reduce climate impacts in practice, research, and policy. Reducing emissions will require changes in both the approach and treatments provided by health care professionals. Nurses can take actions to reduce emissions while not harming patients. For example, in most cases, asthma patients can be safely moved from metered-dose inhalers to dry-powder inhalers, very significantly reducing the total amount of carbon dioxide and other greenhouse gases emitted in asthma management. In Scandinavian countries, 90% of inhalers are now dry-powder, and health outcomes remained the same (Wintemute & Miller, 2020; Woodcock et al., 2022).

More broadly, though the production, transportation, and disposal of health care goods is very climate intensive, nurses can help practice sites make better choices. For example, nurses can encourage practice sites to adopt environmentally preferable purchasing or sustainable procurement which aims to reduce harm to human health and the environment by integrating environmental considerations into all stages of the purchasing process and to reduce use of fossil fuels by encouraging energy efficiency and use of renewable, nonpolluting energy sources. Examples and resources to support these efforts are available through organizations like Health Care without Harm, Practice Green Health, and the Alliance of Nurses for Healthy Environments.

The public recognizes nursing as the most trusted profession (Brenan, 2023). Nurses can leverage that trust to educate policy makers on the health effects of climate change and advocate for policies that promote reduced sources of climate change pollutants (Saad, 2022). Nurses can be advocates for reducing reliance on fossil fuels to improve air quality and mitigate climate change by acting both as constituents and as educators for local legislators on how policy decisions can affect human health, particularly the health of women and children.

CLINICAL IMPLICATIONS

- Educate pregnant women to monitor the air quality forecast, especially during the summer months and avoid being outside as much as possible when the air quality is poor.
- Promote and support breastfeeding to help safeguard human and planetary health by minimizing environmental harm and contributions to climate change.
- Educate women about sources of health risks related to environmental exposures during periods of extreme weather and natural disasters.
- Consider the carbon footprint of the care provided and advocate for the use of safer substitutions wherever possible.
- As members of the most trusted profession, leverage that trust to educate policy makers on the health impacts of climate change and advocate for policies that promote reduced sources of climate change pollutants.

Conclusion

Nurses practicing in perinatal, neonatal, midwifery, and pediatric specialties can play a vital role in advancing the state of the science and translating findings to increase

public understanding about the link between climate change and health. These actions can foster important strategies to improve the health of women and the children who depend on them for protection. ✣

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