



# Climate Change and State of the Science for Children's Health and Environmental Health Equity

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**Introduction:** Climate change is impacting the physical and mental health of children and families. This is a state of the science update regarding the impacts of climate change for pediatric-focused health care providers and advanced practice registered nurses.

**Method:** Using an equity lens, the authors reviewed and synthesized current literature regarding the adverse impacts of climate change.

**Results:** The poor and communities of color are disproportionately impacted by climate change. Physical health impacts include increased vector and water-borne infectious diseases, increases in asthma and respiratory infections, and undernutrition. Social disruptions lead to human trafficking. Climate change is associated with mental health concerns, including anxiety and posttraumatic stress after natural disasters.

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**Discussion:** As clinicians, pediatric-focused providers, and advanced practice registered nurses should use multipronged and interdisciplinary approaches to address or prevent the adverse impacts of climate change. Advocacy at all government levels is necessary to safeguard children and vulnerable populations. *J Pediatr Health Care.* (2022) 36, 20-26

## KEY WORDS

Child health, health equity, environmental justice, climate change

## INTRODUCTION

Climate change is a global crisis disproportionately impacting children and vulnerable populations (Ahdoot, Pacheco, & Council on Environmental Health, 2015; Ebi & Hess, 2020; Philipsborn & Chan, 2018). In the United States, serious climate events are occurring at an increasingly rapid rate. There are major shifts inland and ocean temperatures and increased numbers of natural disasters such as hurricanes, flooding, and fires creating a public health emergency (Tong & Ebi, 2019). Indigenous populations, children of color, those living in poverty, children with chronic health conditions, and those who have developmental disabilities face increased risks in serious climate events (Goldhagen et al, 2020; Nicholas & Breakey, 2017).

In addition to major climate events, rising temperatures cause heatwaves with resultant heat-related illness, leading to increased numbers of emergency visits for children and youth aged under 15 years (Sorensen et al, 2020). Exposure to heat stress during pregnancy is associated with low birth weight, preterm birth, and increased postpartum depression, all of which are associated with adverse child health outcomes (Roos et al, 2021). Because of the long-term effects

of climate change, children globally are facing a lack of adequate water supply and poor food production (2015). This lack of basic resources is leading to an increasing number of environmental refugees and the exploitation of children, including child trafficking (2015; Wood, 2020).

Children are particularly vulnerable to the effects of climate change because of their innate physiology, relatively large body surface area compared with body mass, and their dependence on others for basic needs (Stanberry, Thomson, & James, 2018). Social and economic determinants intersect with biological vulnerability to adversely affect child health. Existing health and socioeconomic disparities are negatively impacted by the effects of climate change, further exacerbating children's vulnerability (Leffers, Levy, Nicholas, & Sweeney, 2017).

Pediatric-focused advanced practice registered nurses (APRNs) have a critical role in responding to this public health crisis (Global Climate Change and Children's Health, 2015; Kurth, 2017). This article, although not a systemic review, is a state of the science review that summarizes and highlights recent literature covering important impacts of climate change on child health, explores approaches to protecting the health of children and vulnerable populations, and discusses advocacy for improved public health policy to mitigate the effects of climate change on child health outcomes.

## INFECTIOUS DISEASE

Worldwide, children bear the highest-burden (88%) of all diseases associated with climate change (Philipsborn & Chan, 2018). Vector-borne diseases, such as Lyme Disease, dengue fever, malaria, and Zika, are sensitive to temperature and climate change leading to increases in the range of the vectors and length of seasons (Caminade, McIntyre, & Jones, 2019; Fouque & Reeder, 2019). Increases in other vector-borne diseases such as West Nile Virus and chikungunya have recently been observed in the United States (Crimmins et al., 2016). Children's typical play behaviors, playing on the ground and spending time outdoors, make them more vulnerable to these vector-borne illnesses increasing their disease burden (Gamble et al., 2016).

The transmission of waterborne infectious diseases is also increased by rising temperatures, humidity, increased insect and animal populations, and changes in precipitation (Crimmins et al., 2016; Watts et al., 2019; World Health Organization, 2018). Cases of non-cholera *Vibrio* illnesses (both foodborne and non-foodborne gastrointestinal diseases with diarrhea and abdominal pain and skin infections) have increased in the United States and are associated with ocean warming (Logar-Henderson, Ling, Tuite, & Fisman, 2019). Excluding Florida, the Atlantic coastline of the United States has experienced a 24% increase in *Vibrio* conditions between 2006 and 2014 (Centers for Disease Control and Prevention, n.d.), and 2018 was ranked second highest in the most suitable water conditions for *Vibrio* infections (Watts et al., 2019). Enteric pathogens are sensitive to temperature, and there have been increases in infections from more common viruses such as *Norovirus*, and bacteria

including *Escherichia coli*, *Salmonella*, and *Shigella* (Walker, 2018).

Globally, diarrheal diseases kill over 500,000 children aged 5 years and under annually, and the rate is expected to increase with increased global temperatures (Philipsborn & Chan, 2018). Children are particularly vulnerable to diarrheal diseases and face a more significant impact from the fever, dehydration, and malnutrition resulting from these diseases. These risks are even greater in the first year of life (Clark et al., 2020; Perera, Ashrafi, Kinney, & Mills, 2019; Philipsborn & Chan, 2018; Watts et al., 2019). The World Health Organization predicts that an additional 48,000 deaths per year from a diarrheal disease will occur by 2030 in children aged less than 15 years (Philipsborn & Chan, 2018).

## FOOD AND WATER SUPPLY

Poor quality nutrition and its adverse consequences are well established as a key indicator of child health and development with lifelong impact (Swinburn et al., 2019). In 2019, the Intergovernmental Panel on Climate Change reported that climate change is the number one global driver of undernutrition, which includes nutrient deficiencies, stunting, and wasting (Swinburn et al., 2019). Of grave concern are the effects of rising sea levels, wildfires, warmer ocean temperatures, storms, floods, droughts, and coastal erosion on food systems (Swinburn et al., 2019). These natural disasters and events associated with global warming impact the availability and affordability of nutritious foods, as evidenced by decreases in crop production globally and increases in food costs (Kurth, 2017). Crop failure, decreased food production, weather-related events, increases in foodborne illness, and infectious diseases depict how climate change, undernutrition, and obesity are interrelated (Nicholas & Breakey, 2017). Their interconnectedness is described by the Lancet Commission on Obesity as a *global syndemic* (the synergistic pandemics of climate change, obesity, and undernutrition), impacting people in all countries and regions of the world, most notably, food-insecure populations (Swinburn et al., 2019).

Historically, malnutrition was seen as the greatest concern when addressing child nutritional health. However, undernutrition in the form of obesity has overtaken malnutrition as a key concern for the nutritional health of children both in the United States and globally (Swinburn et al., 2019). When nutritious foods are not easily accessible for consumption, children and families often turn to highly processed food options. Processed foods are directly associated with increased rates of obesity and undernutrition. The Lancet Commission on Obesity (Vercauteren, Frelief, Lowery, Moran, & Bleich, 2018) calls for nations to systematically, collaboratively, and urgently address the global syndemic of climate change, undernutrition, and obesity to improve health and wellbeing outcomes (Swinburn et al., 2019).

Access to clean drinking water is essential to child health and nutrition. Greenhouse gas emissions, increased pollution and contamination of waterways, and water

overextraction contribute to ground and water pollution, negatively impacting the quality of drinking water (Swinburn et al., 2019). Examples such as the Flint, MI water crisis, in which the community source of drinking water was contaminated with lead, display the direct link between water pollution and the life-lasting health implications for children in this community, including neurocognitive impairment (Hanna-Attisha, LaChance, Sadler, & Champney Schnepf, 2016). Fracking and the presence of heavy metal seepage into the water supply also have known detrimental health consequences and disproportionately impact low-income communities and communities of color (Carpenter, 2016; Vercammen et al., 2018). In the absence of clean drinking water, families resort to alternative, bottled beverage sources. These alternative beverages include sugar-saturated drinks such as sodas and juices (Swinburn et al., 2019; Vercammen et al., 2018). Thus, access to clean drinking water is also linked to the global syndemic and obesity prevention (Swinburn et al., 2019; Vercammen et al., 2018).

Natural disasters contribute to waterborne diseases and illnesses through the presence of pathogens and chemicals. These disasters render water sources contaminated and undrinkable, resulting in increased morbidity and mortality of vulnerable populations because of water scarcity (Kurth, 2017; Veenema et al., 2017). Flooding from tropical storms and hurricanes can also destroy water sources, including springs and wells, threatening water quality through contamination with wastewater. Poor infrastructure and water transportation disruptions that result from these natural disasters can significantly impact access to alternative sources of clean drinking water, impacting child growth and development and overall child health outcomes (Veenema et al., 2017).

### AIR QUALITY AND ASTHMA IN CHILDREN

Increasing temperatures and weather events lead to increasing amounts of pollen and a longer duration of the pollen season, causing increases in asthma and allergic rhinitis in sensitive children (Poole et al., 2019). Asthma is the most common chronic respiratory disease in childhood, and the incidence of asthma has increased globally during the past four decades (Serebrisky & Wiznia, 2019). Asthma is a significant public health problem disproportionately affecting children in communities of color (Patel & Teach, 2019). Young children are particularly vulnerable because of immature respiratory systems, poorly developed intercostal muscles, and smaller airways (Saikia & Mahanta, 2019). Children are often mouth breathers during physical activity and are exposed to more pollen and pollutants during play than adults bypassing filtration in the nasal passages (George, Bruzzese, & Matura, 2017).

Weather events and associated flooding lead to increased indoor pollutants such as molds (Poole et al., 2019). Exposure to molds is associated with increased rates of asthma in children (Garcia et al., 2019). Wildfires, associated with climate change, cause greenhouse gas emission, airborne toxin release, and high levels of particulate matter, all of which are

associated with increased emergency room visits, respiratory infections, and asthma exacerbations (Adetona et al., 2016; Reid et al., 2019; Xu et al., 2020). The release of greenhouse gases from industry and transportation, including carbon dioxide, methane, nitrous oxide, and fluorinated gases associated with climate change, contribute to increased rates of asthma in vulnerable populations (U.S. Environmental Protection Agency, 2020).

Long-term exposure to ozone in the lower levels of the atmosphere is associated with decreased lung function, increasing the risk for asthma and respiratory diseases (Dimakopoulou et al., 2020). Elevated temperatures, heat stress, and poor air quality can contribute to decreases in physical activity, negatively impacting health, especially with asthma and underlying respiratory conditions (George et al., 2017).

### TRAUMA AND MENTAL HEALTH

Children who are displaced when communities are destroyed by droughts, floods, and fires are especially vulnerable to the direct impacts of climate change and have long-lasting emotional, financial, social, and physical effects (Salas, Jacobs, & Perera, 2019). The impacts of displacement can leave children without the normal protective systems of their family and society (2015; Wood, 2020). Displaced children are often less trusting of adults with authority, including health care personnel (Wood, 2020). In a scoping review, Clemens, von Hirschhausen, & Fegert, 2020 describe both indirect and direct effects. The direct effects of climate change and extreme weather events such as floods, hurricanes, and fires cause both physical and emotional trauma. Children and adolescent's knowledge and understanding of climate change can lead to feelings of impending disaster and indirectly lead to stress, fear, and anxiety (Clemens, von Hirschhausen, & Fegert, 2020; Strife, 2012).

Research clearly demonstrates the relationship between adverse childhood experiences (ACEs) and neurobiological changes that can affect physical and mental health throughout life (Felitti et al., 1998). The number of children affected by ACEs is difficult to ascertain as many studies have been retrospective using adult participants (Crouch, Probst, Radcliff, Bennett, & McKinney, 2019). ACEs often result in heightened awareness of threatening stimuli and activation of the stress response (State of California Department of Health Care Services, 2021). Disasters have been associated with significant levels of stress for those children most severely affected through the loss of family members or a home (Bothe, Olness, & Reyes, 2018). Clinicians should expect children who have experienced prolonged stress and adversity to have more severe symptoms and be at increased risk for multiple physical and mental health comorbidities (Herzog & Schmahl, 2018).

Prenatal stress also has negative impacts on child development. In a longitudinal study following women who were pregnant during a severe ice storm in Quebec, maternal distress after the natural disaster leading to posttraumatic stress was found to have significant adverse effects on their

children's developmental outcomes, including reduced intelligence quotients (King, Dancause, Turcotte-Tremblay, Veru, & Laplante, 2012).

Mental health and cognitive functioning are interrelated. Prolonged stress leads to malfunctioning physiological mediators and increased stress hormones such as cortisol. This leads to changes in brain structure and function and long-term adverse health consequences, including increased risks for cardiovascular disease (Shonkoff, Garner, Committee on Psychosocial Aspects of Child and Family Health, Committee on Early Childhood, Adoption, and Dependent Care, & Section on Developmental and Behavioral Pediatrics, 2012). Prolonged, or toxic stress, interacts with genetic and environmental factors and can lead to adverse cognitive outcomes, including poor academic performance and long-term mental health disorders (Boyce, Levitt, Martinez, McEwen, & Shonkoff, 2021). Social support can mediate the adverse impact of long-term stress (Shonkoff, Boyce, Levitt, Martinez, & McEwen, 2021). Chronic stress and anxiety will seriously impact neurodevelopment and physical health as weather-related events increase in frequency and severity (Perera, 2017). Natural disasters can impact mental health by increasing feelings of hopelessness, helplessness, anxiety, and depression and result in posttraumatic stress disorder. The impacts of trauma are especially harmful to children as the safety and wellbeing of the home, school, and community is upended (Fullerton et al., 2013; Hayes, Blashki, Wiseman, Burke, & Reifels, 2018; Vins, Bell, Saha, & Hess, 2015). Social support mediated mental health problems in children and youth after Hurricane Katrina (Lai, Osborne, Piscitello, Self-Brown, & Kelley, 2018). Identifying children and youth with inadequate social support affords the opportunity to help develop supportive and protective relationships to mitigate risks of long-term posttraumatic stress.

As climate change leads to increases in food insecurity, associated mental health issues also increase. Preschool children facing food insecurity have higher rates of behavioral problems (Whitaker, Phillips, & Orzol, 2006), and food insecurity is associated with higher rates of depression and anxiety at school age (Melchior et al., 2012).

## EQUITY AND ENVIRONMENTAL JUSTICE

Children of color are more likely to face adverse impacts of climate change because of the historical practice of redlining, in which banks identified neighborhoods with a high concentration of Blacks or immigrant populations as "high risk" and refused to give access to mortgages and other loans (Nardone, Chiang, & Corburn, 2020). The intersection of systemic racism and climate change has been documented in 108 communities throughout the United States, in which these previously red-lined neighborhoods have higher temperatures and fewer trees (Hoffman, Shandas, & Pendleton, 2020). Poor communities of color in Michigan disproportionately experience heat stress (Koman et al., 2019). Poor, rural populations in the Southeast face risks from flooding, extreme weather events, exposure to toxic chemicals, heat waves, and increasing rates of asthma (Gutierrez & LePrevost, 2016).

Increased temperatures have a detrimental impact on academic achievement, disproportionately affecting Black and Hispanic/Latino students in the United States whose schools often do not have air conditioning (Park, Behrer, & Goodman, 2021). Formerly red-lined neighborhoods are often in proximity to industrial areas, and children living in these urban areas have increased exposure to particulate matter and higher rates of asthma and respiratory illnesses (Oliveira, Slezakova, Delerue-Matos, Pereira, & Morais, 2019).

Children and families from marginalized communities in the United States and globally face the highest risks from climate change because of underlying poverty and risk from societal disruptions (Hayes et al., 2018; Randolph, Chacko, & Morsch, 2019). Climate change will have the biggest adverse impact on children in low and middle-income countries who are at high risk for food insecurity, infectious diseases, injury and death related to severe storms, and political conflict resulting in forced migration related to loss of resources (Philipsborn & Chan, 2018).

Children are also at increased risk for trafficking when they lose the protection of social networks and are exposed to familial and societal adversity, rejection, armed conflict, or climate emergencies. Of the estimated 40 million victims of trafficking worldwide, one in four are children (Wood, 2020). In the United States, the chaos and disruption that follows natural disasters caused by climate change have led to human trafficking (Polaris, 2017). During times of societal disruptions, predators seek out the most vulnerable, including those children and families who are homeless or displaced (Gerrard, 2018; Polaris, 2017; Randolph et al., 2019).

## ADVOCACY TO MITIGATE EFFECTS OF ENVIRONMENTAL INJUSTICE

The intersection of social justice and adverse impacts of climate change requires a multipronged response, including advocacy (Nicholas & Breakey, 2017). Advocacy efforts require an equity lens at the national, state, and local level to limit further environmental degradation and remediate the impacts of climate change (Nicholas & Breakey, 2017). Under-resourced children and youth face the highest risks from climate change, and pediatric providers and pediatric-focused APRNs need to be aware of environmental threats locally, nationally, and globally because climate change knows no borders (Miller, Marty, & Landrigan, 2016). Advocacy should include improved urban planning and the development of green spaces to address the adverse impact of rising temperatures and limits on emissions near playgrounds and schools to prevent exposure to pollutants. Implementation of a regulatory program to reduce greenhouse gas emissions was found to avoid adverse health outcomes for children and save up to \$8.1 million from 2009 to 2014 (Perera, Cooley, Berberian, Mills, & Kinney, 2020).

Advocacy efforts should also include supporting systemic change in health care delivery and accessibility. Caring for children and families stressed by environmental disasters requires reconceptualizing health care provision to allow

adequate time to respond to children's needs and foster resilience (Shonkoff et al., 2021). Emergency preparations for climate-related natural disasters must include planning for the special pediatric populations, including children and youth with special health care needs. Preparations require planning to meet educational, mental health, and physical needs and the provision of adequate pediatric medical equipment and supplies (Bothe et al., 2018; Stanberry et al., 2018). In clinical settings, pediatric-focused APRNs should work to develop sustainable, climate-friendly practices and minimize waste associated with climate change (Corvalan et al., 2020; Frumkin, 2021).

Planetary health, environmental justice, and access to nutritious foods are intricately linked and have a multifaceted impact on child health and nourishment (Kurth, 2017). Climate change impacts food and water resources and has the grave potential of disproportionately impacting children's health over the next generation (Ahdoot, Pacheco, & Council on Environmental Health, 2015). Advocacy for improved public health policy is essential to developing collaborative, evidence-based solutions that address the health consequences of climate change on child health outcomes.

Children depend on adults to advocate for them in policy decisions (Nicholas & Breakey, 2017). A significant, unified commitment to implementing climate change policy is essential to mitigating and preventing further effects of global warming and protecting child health. Predisaster planning should include preparation to meet the physical, health, mental health, and educational needs of all children and youth (Bothe et al., 2018). All children are vulnerable to the impact of climate change, but those who live in poverty and communities of color are disproportionately impacted, and pediatric providers and pediatric-focused APRNs must use interdisciplinary, collaborative approaches with affected communities to respond to this immediate and long-term threat to child wellbeing (Goldhagen et al., 2020).

## CONCLUSIONS

Climate change is adversely affecting the health and wellbeing of children and families throughout the globe, with the most severe impacts experienced by children of color or those living in poverty (Miller et al., 2016). Rising rates of vector and waterborne illnesses, respiratory diseases, undernutrition, and mental health concerns call for primary, secondary, and tertiary preventive measures (Stanberry et al., 2018; Tong & Ebi, 2019). Pediatric providers and pediatric-focused APRNs are on the frontlines providing access to culturally sensitive, family-focused care, addressing social determinants of health while providing expert clinical care (NAPNAP, 2017). Early identification of children and families most at risk allows interventions to improve health care and mitigate climate-related risks. Pediatric-focused APRNs must work to develop interprofessional systems of care to support the resilience and mental health of children and families impacted by climate change (Clemens, von Hirschhausen, & Fegert, 2020) and work with local organizations, health departments, and schools to

develop primary, secondary, and tertiary public health interventions to prevent and address immediate and long-term health impacts of climate change to improve child health outcomes (Tong & Ebi, 2019).

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