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Review

The impact of climate change on pediatric health: a literature review on emerging risks

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Abstract

Climate change represents one of the most significant global health threats of the 21st century, with children being particularly vulnerable to its effects. This literature review examines the emerging risks posed by climate change on pediatric health, highlighting the multifaceted impacts on respiratory health, heat-related illnesses, vector-borne diseases, nutrition, mental health, and exposure to waterborne pathogens. Additionally, the review explores the disproportionate effects on children from marginalized communities, underscoring the urgent need for targeted interventions and policies. By synthesizing current research, this article aims to raise awareness among healthcare professionals and policymakers about the pressing need to protect pediatric populations from the evolving challenges of climate change.

Keywords

Pediatric health, climate change, emerging risks, environmental health, public health interventions.

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Introduction

Climate change, driven largely by human activities such as fossil fuel combustion and deforestation, has emerged as a critical global challenge, with profound impacts on health and well-being. The earth's climate is undergoing rapid changes, including rising temperatures, shifting precipitation patterns, and an increase in the frequency and severity of extreme weather events. These changes have far-reaching implications, particularly for vulnerable populations, including children [1].

Children are uniquely susceptible to the health impacts of climate change due to their developing physiology, higher exposure to environmental hazards, and dependence on caregivers for protection and care. Unlike adults, children breathe more air relative to their body weight, have a higher metabolic rate, and their bodies are still growing and developing, making them more sensitive to pollutants and temperature extremes [2]. Additionally, children are more likely to suffer from the secondary effects of climate-related disruptions, such as displacement, food insecurity, and the spread of infectious diseases [3].

Given these vulnerabilities, the intersection of climate change and pediatric health demands urgent attention. This literature review seeks to explore the emerging risks that climate change poses to pediatric populations, with a focus on understanding how these risks manifest and what strategies can be employed to mitigate them [4]. The objectives of this review are to provide a comprehensive overview of the current state of knowledge on the subject, identify gaps in the literature, and suggest directions for future research. By doing so, this review aims to contribute to the growing body of evidence needed to inform public health interventions and policy decisions that protect the health and well-being of children in the face of a changing climate [5].

Methodology

This literature review was conducted using a systematic approach in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, ensuring a comprehensive and unbiased selection of relevant studies. The methodology involved several key steps: database selection, search strategy development, study selection, data extraction, and quality assessment.

Database selection

The search for relevant literature was conducted across multiple reputable databases, including PubMed, Google Scholar, Scopus, and Web of Science. These databases were chosen for their extensive coverage of medical, environmental, and public health literature, ensuring that the review captured a broad range of studies relevant to the impact of climate change on pediatric health.

Search strategy

A precise and systematic search strategy was developed in consultation with a research librarian to ensure comprehensive retrieval of relevant studies. The search terms included a combination of keywords and MeSH (Medical Subject Headings) terms related to the topic. The main keywords used were "Pediatric Health," "Climate Change," "Emerging Risks," "Environmental Health," and "Public Health Interventions." Boolean operators (AND, OR) were employed to combine terms effectively, and the search was limited to studies published in English.

The search strategy was iteratively refined to enhance sensitivity and specificity. Searches were performed across all databases, and reference lists of selected articles were also hand-searched to identify any additional studies that might have been missed in the initial search.

Study selection

The inclusion criteria for studies were established prior to the search to ensure consistency and relevance. These criteria included:

- language: only articles published in English were considered;
- population: studies focusing specifically on pediatric health (children and adolescents up to 18 years of age);
- focus: research reporting on the impact of climate change on pediatric health, including emerging risks and associated public health interventions;
- study type: both observational and experimental studies, including case studies, cohort studies, cross-sectional studies, and systematic reviews, were included.

An initial search yielded 133 articles. After the removal of duplicates, 94 articles remained. These articles were then screened based on their titles and abstracts by two independent reviewers. Articles

that clearly did not meet the inclusion criteria were excluded. The remaining articles (n = 58) underwent full-text review, resulting in a final selection of 32 articles that met all the inclusion criteria.

To provide a clear overview of the study selection process, the PRISMA flow diagram is included below (**Fig. 1**), illustrating the number of records identified, screened, and included in the review, along with reasons for exclusion.

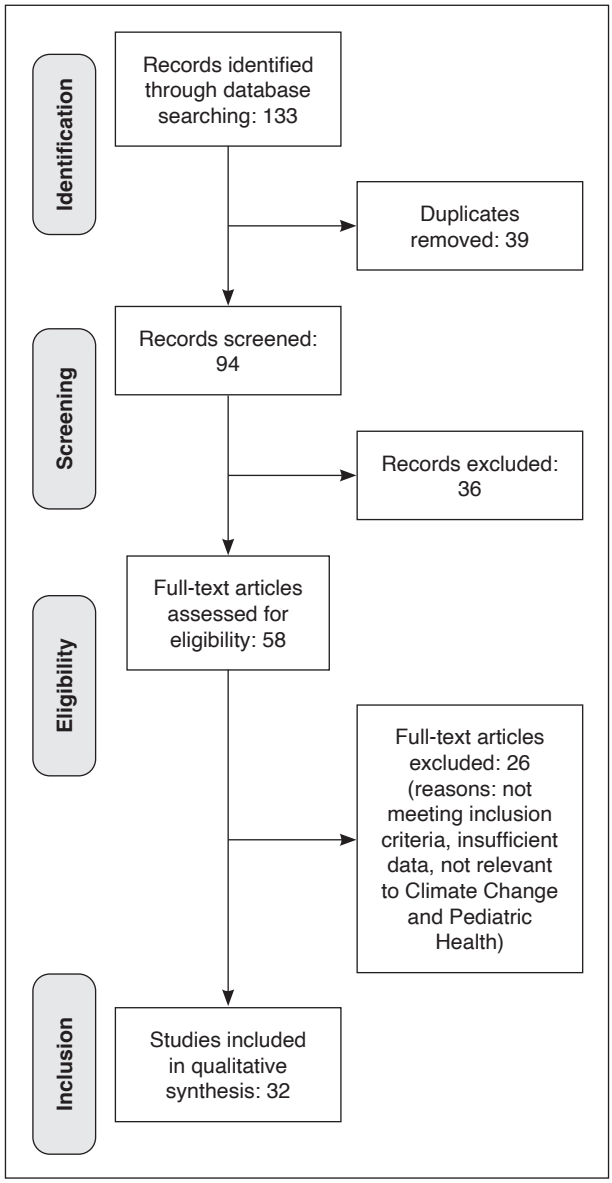

Figure 1. The PRISMA flow diagram.

Data extraction

A standardized data extraction form was developed to systematically gather relevant information from each included study. The data extraction process was performed independently by two reviewers to minimize errors and bias. Key information extracted included study design, population characteristics, climate-related exposures, health outcomes, and key findings related to pediatric health. Discrepancies between the reviewers were resolved through discussion and consensus, with a third reviewer consulted if necessary.

Quality assessment

To assess the quality and risk of bias in the included studies, the Joanna Briggs Institute (JBI) Critical Appraisal Tools were utilized for different study designs. Each study was assessed for methodological rigor, clarity of reporting, and relevance to the review question. Studies were classified as high, moderate, or low quality based on these criteria. This quality assessment was integral in interpreting the results and drawing conclusions from the literature review.

Data synthesis

The findings from the included studies were synthesized qualitatively, with a focus on identifying common themes, emerging risks, and potential interventions. The synthesis aimed to provide a comprehensive overview of the current state of knowledge on the impact of climate change on pediatric health and to highlight areas where further research is needed.

Respiratory health and air quality

The respiratory health of children is increasingly jeopardized by the escalating levels of air pollution, a consequence of industrialization, urbanization, and climate change. Air pollution, particularly the rise in fine particulate matter (PM2.5) and other airborne pollutants, has become a critical concern for pediatric health. Children are especially vulnerable due to their developing respiratory systems, higher minute ventilation per body weight, and the fact that they often engage in outdoor activities, increasing their exposure to polluted air [6].

PM2.5 refers to airborne particles with a diameter of less than 2.5 micrometers, small enough to bypass the upper respiratory defenses and penetrate deep into the lungs. Once inhaled, these particles can cause significant inflammation in the airways, leading to conditions such as asthma, bronchitis,

and other chronic respiratory diseases. Children exposed to high levels of PM2.5 are at a higher risk of developing asthma, with studies indicating that early-life exposure can alter lung development and immune responses, predisposing them to chronic respiratory issues [7]. This is particularly concerning in urban environments where PM2.5 levels are frequently elevated due to traffic emissions, industrial activities, and, increasingly, wildfires driven by climate change.

Asthma is now the most prevalent chronic disease among children, and its incidence is rising in tandem with worsening air quality. The Global Initiative for Asthma (GINA) reports that air pollution is a significant trigger for asthma exacerbations, leading to increased hospital admissions, missed school days, and a reduced quality of life for affected children [8]. The pathophysiology of asthma exacerbated by air pollution involves a complex interplay between genetic predisposition and environmental factors. Pollutants such as ozone, nitrogen dioxide, and PM2.5 contribute to airway inflammation, hyperresponsiveness, and oxidative stress, which are key mechanisms in asthma pathogenesis.

Moreover, the impact of air pollution on pediatric respiratory health is not uniform but varies with seasonal changes. During winter, for instance, the combination of increased particulate emissions from heating sources and meteorological conditions that trap pollutants close to the ground leads to spikes in air pollution levels. These seasonal variations correlate with higher rates of respiratory infections and asthma exacerbations in children [6]. Additionally, climate change-induced phenomena such as prolonged pollen seasons and more frequent wildfires further contribute to deteriorating air quality and respiratory health in children.

Children from socioeconomically disadvantaged backgrounds are disproportionately affected by poor air quality. These children often live in areas with higher pollution levels due to proximity to industrial zones or major roadways and may lack access to adequate healthcare. This exacerbates health disparities, as these children are more likely to suffer from severe asthma and other respiratory conditions without timely and effective treatment [8].

Heat-related illnesses

Children are particularly vulnerable to heat stress and heat-related illnesses due to their unique physiological and behavioral characteristics. Their bodies generate more heat during physical activity and have a lower capacity to sweat compared to adults, which makes it harder for them to regulate body temperature effectively. Additionally, children tend to spend more time outdoors during peak heat periods, further increasing their exposure to extreme temperatures. These factors contribute to a heightened risk of heat-related illnesses in pediatric populations [9].

The correlation between rising global temperatures and the incidence of heat-related illnesses in children is well-documented. Even small increases in temperature can lead to a significant rise in Emergency Department visits for conditions such as heat exhaustion, dehydration, and heatstroke. These conditions are particularly dangerous for children because their bodies can become overwhelmed quickly, leading to potentially life-threatening situations if not treated promptly. Moreover, heat stress can exacerbate pre-existing conditions like asthma and cardiovascular diseases, leading to more severe health outcomes in children [10].

Urban environments, especially those characterized by "heat islands," present additional risks. Urban heat islands are areas within cities that experience significantly higher temperatures than surrounding rural areas due to human activities and the concentration of heat-absorbing materials such as asphalt and concrete. The lack of vegetation and green spaces in these areas further intensifies the heat, creating environments that are particularly hazardous for children. Increased temperatures in urban heat islands have been linked to higher incidences of heat-related illnesses, respiratory problems, and even impacts on cognitive development and academic performance in children [10].

The impact of heat on pediatric health also varies seasonally, with a significant increase in heat-related illnesses observed during the summer months, especially in regions experiencing heat waves. Children in low-income communities are particularly vulnerable as they may lack access to air conditioning or other cooling mechanisms, making them more susceptible to the adverse effects of high temperatures [9].

Vector-borne diseases

The impact of climate change on vector-borne diseases is increasingly evident as rising temperatures and shifting precipitation patterns expand the geographic range of disease-carrying

vectors like mosquitoes and ticks. This expansion, coupled with the introduction of new vector species into previously unaffected regions, is resulting in a growing number of pediatric cases of diseases such as malaria, dengue, Zika, and Lyme disease.

As climate change drives warmer temperatures, vectors such as Aedes mosquitoes, which transmit dengue, Zika, and chikungunya, are migrating to higher altitudes and latitudes. This shift has led to the emergence of these diseases in regions where they were previously rare or non-existent. For example, the spread of dengue and chikungunya in Europe and the southern United States illustrates the expanding threat posed by these vectors [11]. The rise in global temperatures also facilitates longer seasons of vector activity, thereby increasing the duration of exposure to these diseases [12].

Children are particularly vulnerable to vector-borne diseases due to their developing immune systems and greater exposure to outdoor environments where vectors thrive. In regions like sub-Saharan Africa, where healthcare infrastructure is already strained, the rising incidence of these diseases poses a significant public health challenge. This situation is exacerbated by socioeconomic factors, such as poverty and lack of access to preventive measures, which heighten the vulnerability of pediatric populations [13].

Moreover, the interplay between climate change and urbanization creates environments conducive to the proliferation of vectors. Urban heat islands, characterized by higher temperatures in cities compared to surrounding rural areas, further amplify the risk of vector-borne diseases. These areas provide ideal breeding grounds for mosquitoes, especially in water storage containers and poorly managed waste sites, which are common in rapidly growing urban centers in low- and middle-income countries [14].

Nutrition and food security

Climate change significantly impacts global agriculture and food security, with serious implications for pediatric health, particularly in terms of nutrition and food security. Rising global temperatures, increased frequency of extreme weather events, and shifts in precipitation patterns directly affect agricultural productivity, which in turn influences the availability and quality of food. This environmental instability disrupts food production systems, leading to reduced crop yields, loss of arable land, and diminished food diversity, all of which are essential for maintaining adequate nutrition in children [15, 16].

Children are particularly vulnerable to the adverse effects of food insecurity and malnutrition caused by climate change. In many regions, the decline in agricultural output has led to increased food prices, making nutritious food less accessible, especially for low-income families. The result is a higher incidence of nutritional deficiencies in children, including protein-energy malnutrition and deficiencies in essential vitamins and minerals such as iron, zinc, and vitamin A. These deficiencies can have long-lasting effects on a child's physical and cognitive development, potentially leading to stunted growth, weakened immune systems, and lower academic performance [17, 18].

The impact of climate change on food security is not uniform across the globe. Certain regions, particularly those in developing countries, are more severely affected due to their reliance on rain-fed agriculture and limited resources to adapt to changing conditions. In these areas, children are more likely to experience the detrimental effects of food scarcity and malnutrition, exacerbating existing health disparities. Additionally, climate change is expected to increase the frequency of extreme weather events, such as droughts and floods, which further disrupt food production and exacerbate food insecurity [16, 19].

Moreover, the nutritional quality of food is also being compromised by climate change. Elevated levels of atmospheric carbon dioxide (CO_2) have been shown to reduce the concentrations of essential nutrients in staple crops like wheat, rice, and legumes. This phenomenon, known as the "carbon nutrient penalty," decreases the protein content and vital micronutrients such as iron and zinc in these foods, further contributing to the risk of malnutrition in children who rely heavily on these staples for their daily nutritional intake [15, 17].

Mental health impacts

Climate change poses significant threats to pediatric mental health, particularly through its impact on extreme weather events and environmental stressors. Children are especially vulnerable to the psychological effects of climate-related disasters, such as hurricanes, floods, wildfires, and prolonged droughts. These events often lead to immediate and long-term mental health challenges, including anxiety, depression, and post-traumatic stress disorder (PTSD) [20, 21].

Children's heightened vulnerability can be attributed to several factors. They are more likely than adults to experience severe trauma and disruption in their lives following a disaster. The loss of home, separation from caregivers, and the destruction of their familiar environment can be profoundly destabilizing. Furthermore, the ongoing stress from living in disaster-prone areas or under the threat of extreme weather events can lead to chronic anxiety and other stress-related disorders. These conditions may not only affect the child's emotional well-being but can also impede cognitive development and academic performance [20, 21].

Additionally, the rise in global temperatures is linked to an increase in mental health issues among children. Heatwaves and high ambient temperatures are associated with a greater incidence of aggressive behavior, substance abuse, and even suicide in affected populations. Children, who are still developing coping mechanisms, may struggle more than adults to manage these stressors, leading to long-term psychological effects [22].

Urban environments, particularly those with poor infrastructure to manage heat and disasters, exacerbate these issues. The concept of "urban heat islands," where cities experience significantly higher temperatures than their rural counterparts, adds another layer of risk for children. Prolonged exposure to extreme heat without adequate relief can result in both physical and psychological stress, further contributing to the rise in mental health issues among the pediatric population [22].

Waterborne diseases and access to clean water

The effects of climate change on waterborne diseases and access to clean water present significant challenges for pediatric health. Children are particularly vulnerable to these impacts due to their developing immune systems and dependency on clean water for nutrition and hygiene.

Climate change exacerbates the incidence of waterborne diseases by influencing factors such as flooding, droughts, and water contamination. Flooding, for instance, often leads to the contamination of water supplies with pathogens like *Escherichia coli*, cholera, and giardia, increasing the risk of diarrheal diseases in children. As climate change increases the frequency and severity of such weather events, the exposure of children to these pathogens is expected to rise significantly. Droughts, on the other hand, reduce the availability of clean water, concentrating contaminants in limited water sources and forcing communities to use unsafe water, further heightening the risk of disease outbreaks among children [23].

The correlation between climate change and the rise in diarrheal diseases among children is well-documented. Diarrheal diseases are already a leading cause of morbidity and mortality in children under five, and climate change is expected to worsen this burden. Warmer temperatures, altered rainfall patterns, and the increased frequency of extreme weather events create ideal conditions for the proliferation of waterborne pathogens. Studies have shown that ambient temperature increases can elevate the incidence of bacterial diarrhea in children, with regions like sub-Saharan Africa and South Asia being particularly vulnerable [24].

Moreover, ensuring access to clean water is becoming increasingly difficult in the context of climate change. In many regions, infrastructure is insufficient to cope with the increasing variability in water availability, leading to frequent disruptions in water supply. This challenge is particularly severe in urban slums and rural areas where children are most at risk. The lack of access to safe drinking water not only increases the incidence of waterborne diseases but also contributes to malnutrition, as contaminated water is often linked to nutrient loss in children suffering from repeated bouts of diarrhea [25].

Impact of extreme weather events

Extreme weather events, such as hurricanes, floods, and wildfires, present significant challenges to pediatric health, both physically and emotionally. These events are becoming more frequent and severe due to climate change, and children are especially vulnerable due to their developing bodies and dependence on adult care.

Physically, extreme weather events can lead to injuries, respiratory problems from smoke and poor air quality, and exacerbation of chronic conditions like asthma. The chaos during these events often disrupts access to essential healthcare services, further jeopardizing children's health. For example, wildfires not only cause direct harm through burns and smoke inhalation but also displace families, leading to loss of access to regular medical care and medications. Similarly, floods can contaminate drinking water supplies, leading to waterborne diseases that disproportionately affect children [26].

Emotionally, the trauma associated with these disasters can have profound long-term effects. Children exposed to extreme weather events are

at an increased risk of developing anxiety, depression, and PTSD. The disruption of daily life, loss of home, and even the death of loved ones are traumatic experiences that can impact a child's mental health for years. Studies have shown that children who experience such trauma may struggle with these issues long after the event, with some requiring ongoing mental health support [27].

Displacement caused by these events often leads to a breakdown in the social and support networks that are crucial for children's well-being. For instance, after hurricanes or floods, families may be forced to relocate, disrupting children's schooling and social connections, which are vital for their emotional stability and development. Case studies from recent hurricanes and wildfires in the United States have highlighted these impacts, showing that children in affected areas often experience higher rates of mental health issues and lower overall well-being in the years following these events.

Socioeconomic and environmental justice issues

The intersection of socioeconomic disparities and environmental justice is a critical component in understanding the impact of climate change on pediatric health. Climate change exacerbates existing health disparities among children from different socioeconomic backgrounds, particularly affecting those from low-income families and marginalized communities. These children are more likely to live in areas with poorer environmental conditions, such as neighborhoods with higher exposure to air pollution, limited access to clean water, and inadequate housing that cannot effectively protect against extreme weather events. This increased vulnerability stems from structural inequalities that limit access to resources and services that could mitigate the effects of climate change.

Children in low-income families are often more exposed to environmental hazards like polluted air and contaminated water, which directly contribute to higher rates of respiratory illnesses, developmental disorders, and other health issues. For instance, families living in subsidized housing are more likely to experience flooding and inadequate ventilation, which can exacerbate conditions like asthma [28]. Additionally, these families may lack the financial resources to recover from climate-related disasters, such as buying insurance or relocating from hazardous areas, further entrenching their vulnerability.

Environmental justice plays a pivotal role in addressing these disparities. Historically, environmental justice movements have sought to highlight and address the disproportionate burden of environmental hazards on communities of color and low-income populations. These communities are often located in areas with higher environmental risks, such as proximity to industrial sites, landfills, or highways, which contribute to poor health outcomes. The Environmental Protection Agency (EPA) and other organizations have recognized the need to address these inequities through targeted policies and interventions [29].

Policies aimed at promoting environmental justice and reducing health disparities include the Justice40 Initiative, which seeks to ensure that 40% of federal climate-related investments benefit disadvantaged communities. Additionally, public health frameworks like the CDC's BRACE (Building Resilience Against Climate Effects) emphasize the importance of incorporating justice, equity, diversity, and inclusion (JEDI) principles into climate adaptation planning. These efforts are crucial in developing strategies that not only address the immediate health impacts of climate change on children but also tackle the underlying socioeconomic factors that contribute to these disparities [28].

Adaptation and mitigation strategies

Adaptation and mitigation strategies are critical to addressing the significant health challenges that climate change poses to children. As climate change continues to intensify, there is a growing need for innovative public health interventions aimed at mitigating its impact on pediatric health. These strategies encompass a range of approaches, from healthcare delivery to policy innovations and community programs, each designed to protect children's health in the face of climate-related risks.

One of the primary strategies involves improving healthcare infrastructure to enhance resilience against climate-induced shocks. This includes reinforcing hospitals, clinics, and supply chains to withstand extreme weather events and ensuring that healthcare services remain accessible during and after such occurrences. Strengthening climate-health surveillance systems is also essential, enabling early detection of climate-related health risks and facilitating timely interventions to prevent widespread health crises [30].

Healthcare providers play a crucial role in addressing climate-related health risks, particularly

in pediatrics. Pediatricians and other healthcare professionals are increasingly advocating for the integration of climate considerations into healthcare practices. This includes educating families about the health risks associated with climate change, such as heat-related illnesses and respiratory conditions, and promoting behaviors that reduce these risks. Moreover, healthcare providers are essential in advocating for policies that prioritize children's health in climate change mitigation and adaptation efforts. They can influence policy by participating in public discourse, advising on healthcare policies, and collaborating with government agencies and non-governmental organizations (NGOs) to develop comprehensive climate-health strategies [3].

Community-level interventions are also pivotal. Programs that promote environmental sustainability and resilience in local communities can significantly reduce the health impacts of climate change on children. These initiatives often focus on improving access to clean water, enhancing food security, and ensuring that vulnerable populations receive adequate healthcare services during extreme weather events. Furthermore, public awareness campaigns can help communities better understand the links between climate change and health, encouraging proactive measures to protect children from climate-related health threats [30].

Innovations in policy and healthcare delivery are equally important. Governments at all levels are encouraged to develop and implement long-term policies that reduce greenhouse gas emissions and invest in public health infrastructure. This includes funding for research on climate-health linkages, supporting educational programs that raise awareness about climate change's health impacts, and enacting legislation that ensures the protection of children's health in climate policies. These efforts are vital for creating a sustainable future where children's health is safeguarded against the growing threats of climate change [3].

Future directions and research gaps

The future directions and research gaps in studying the impacts of climate change on pediatric health underscore the need for a more comprehensive and interdisciplinary approach. While existing research highlights the immediate risks, such as respiratory diseases, heat-related illnesses, and the psychological impacts of extreme weather, there are significant gaps in understanding the long-term and indirect effects. For instance, the cumulative impact of multiple climate stressors on children's development is not well-studied, nor is the interplay between socio-economic factors and climate vulnerability in pediatric populations [1].

Current studies often focus on isolated aspects of climate change, such as air pollution or temperature increases, without considering the combined effects of these and other factors like food insecurity, vector-borne diseases, and mental health. This narrow focus limits the ability to develop comprehensive mitigation strategies. Additionally, there is a lack of longitudinal studies that track health outcomes over time, which is crucial for understanding the long-term consequences of early childhood exposure to climate-related risks [31].

Another significant gap is the limited research on vulnerable populations, including children from low-income families, Indigenous communities, and those living in high-risk geographic areas. These groups are often disproportionately affected by climate change, yet they are underrepresented in current research. Understanding the unique vulnerabilities of these populations is essential for developing targeted interventions that address both immediate and long-term health risks [32].

Furthermore, there is a need for more interdisciplinary research that integrates perspectives from public health, environmental science, social sciences, and policy studies. This would enable a more holistic understanding of how climate change impacts pediatric health and what strategies could be most effective in mitigating these impacts. For example, combining data from environmental monitoring with health outcomes data could help identify early warning signs of climate-related health issues in children [31].

In terms of future research, there is a pressing need for studies that explore the effectiveness of adaptation and mitigation strategies specifically designed for pediatric populations. This includes evaluating the impact of public health interventions, such as air quality improvement programs and heatwave response plans, as well as broader policy initiatives aimed at reducing carbon emissions and promoting environmental sustainability [1].

Finally, it is crucial to foster greater collaboration between researchers, healthcare providers, policymakers, and communities to ensure that research findings are translated into effective actions. This collaborative approach is essential for closing the existing research gaps and ensuring that future studies are aligned with the real-world needs of vulnerable pediatric populations [32].

Conclusion

In conclusion, climate change poses significant and multifaceted risks to pediatric health, exacerbating existing health disparities and introducing new challenges. The increasing prevalence of respiratory and vector-borne diseases, heat-related illnesses, and mental health issues in children underscores the urgent need for targeted research and comprehensive public health interventions. Addressing these challenges requires a collaborative, interdisciplinary approach that integrates environmental, social, and healthcare strategies. By identifying research gaps and proposing innovative mitigation strategies, this review highlights the critical steps needed to protect future generations from the adverse effects of a changing climate.

Declaration of interest

The Author declares that there are no competing interests.

References

1. Romanello M, Napoli CD, Green C, Kennard H, Lampard P, Scamman D, Walawender M, Ali Z, Ameli N, Ayeb-Karlsson S, Beggs PJ, Belesova K, Berrang Ford L, Bowen K, Cai W, Callaghan M, Campbell-Lendrum D, Chambers J, Cross TJ, van Daalen KR, Costello A. The 2023 report of the Lancet Countdown on health and climate change: the imperative for a health-centred response in a world facing irreversible harms. Lancet (Lond Engl). 2023;402(10419): 2346-94.
2. IPCC; Pörtner HO, Roberts DC, Tignor M, Poloczanska ES, Mintenbeck K, Alegría A, Craig M, Langsdorf S, Löschke S, Möller V, Okem A, Rama B (Eds.). Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and New York, NY, USA: Cambridge University Press, 2022.
3. Ahdoot S, Pacheco SE, Paulson JA, Baum CR, Bole A, Brumberg HL, Campbell CC, Lanphear BP, Lowry JA, Spanier AJ, Trasande L. Global Climate Change and Children's Health. Pediatrics. 2015;136(5):e1489.
4. Ahdoot S, Baum CR, Cataletto MB, Hogan P, Wu CB, Bernstein A. Climate Change and Children's Health: Building a Healthy Future for Every Child. Pediatrics. 2024;153(3):e6.
5. Corvalan C, Gray B, Villalobos Prats E, Sena A, Hanna F, Campbell-Lendrum D. Mental health and the global climate crisis. Epidemiol Psychiatr Sci. 2022;31:1-8.
6. Aithal SS, Sachdeva I, Kurmi OP. Air quality and respiratory health in children. Breathe (Sheff). 2023;19(2):230040.
7. Zhang Y, Yin X, Zheng X. The relationship between PM2.5 and the onset and exacerbation of childhood asthma: a short communication. Front Pediatr. 2023;11:1191852.
8. Zanobetti A, Ryan PH, Coull BA, Luttmann-Gibson H, Datta S, Blossom J, Brokamp C, Lothrop N, Miller RL, Beamer PI, Visness CM, Andrews H, Bacharier LB, Hartert T, Johnson CC, Ownby DR, Khurana Hershey GK, Joseph CLM, Mendonça EA, Jackson DJ, ECHO Children's Respiratory and Environmental Workgroup. Early-Life Exposure to Air Pollution and Childhood Asthma Cumulative Incidence in the ECHO CREW Consortium. JAMA Netw Open. 2024;7(2):e10.
9. Berger SE, Ordway MR, Schoneveld E, Lucchini M, Thakur S, Anders T, Natale L, Barnett N. The impact of extreme summer temperatures in the United Kingdom on infant sleep: Implications for learning and development. Sci Rep. 2023;13(1):10061-70.
10. Cichowicz R, Bochenek AD. Assessing the effects of urban heat islands and air pollution on human quality of life. Anthropocene. 2024;46:100433.
11. Adepoju OA, Afinowi OA, Tauheed AM, Danazumi AU, Dibba LBS, Balogun JB, Flore G, Saidu U, Ibrahim B, Balogun OO, Balogun EO. Multisectoral Perspectives on Global Warming and Vector-borne Diseases: a Focus on Southern Europe. Curr Trop Med Rep. 2023;10(2):47-70.
12. Caminade C, Kovats S, Rocklov J, Tompkins AM, Morse AP, Colón-González FJ, Stenlund H, Martens P, Lloyd SJ. Impact of climate change on global malaria distribution. Proc Natl Acad Sci U S A. 2014;111(9):3286-91.
13. Walker PG, White MT, Griffin JT, Reynolds A, Ferguson NM, Ghani AC. Malaria morbidity and mortality in Ebola-affected countries caused by decreased healthcare capacity, and the potential effect of mitigation strategies: a modelling analysis. Lancet Infect Dis. 2015;15(7):825-32.
14. Eder M, Cortes F, Teixeira de Siqueira Filha N, Coelho GE, Almeida MAB, Nogueira LS, Araujo WN. Scoping review on vector-borne diseases in urban areas: transmission dynamics, vectorial capacity, and co-infection. Infect Dis Poverty. 2018;7:90.
15. Tirado MC, Crahay P, Mahy L, Zanev C, Neira M, Msangi S, Brown R, Scaramella C, Costa Coitinho D, Müller A. Climate change and nutrition: creating a climate for nutrition security. Food Nutr Bull. 2013;34(4):533-47.
16. FAO, IFAD, UNICEF, WFP, WHO. The State of Food Security and Nutrition in the World 2023: Urbanization, Agrifood Systems Transformation and Healthy Diets across the Rural–Urban Continuum. Rome: FAO, 2023.
17. Myers SS, Zanobetti A, Kloog I, Huybers P, Leakey AD, Bloom AJ, Carlisle E, Dietterich LH, Fitzgerald G, Hulshof C, Lickers D, Loladze I, McGrath JM, Redden R, Schwartz J, Seneweera S, Taub DR, Usui Y, Vitousek PM, Westerband AC. Increasing CO2 threatens human nutrition. Nature. 2014;510(7503):139-42.

18. FAO; Bélanger J, Pilling D (Eds.). The State of the World's Biodiversity for Food and Agriculture. Available at: http://www.fao.org/3/CA3129EN/CA3129EN.pdf, date of publication: 2019, last access: July 2024.
19. Bryan E, Ringler C, Meinzen-Dick R. Gender, resilience, and food systems. In: Béné C, Devereux S (Eds.). Resilience and Food Security in a Food Systems Context. Cham: Palgrave Macmillan, 2023.
20. Van Nieuwenhuizen A, Hudson K, Chen X, Hwong AR. The effects of climate change on child and adolescent mental health: clinical considerations. Curr Psychiatry Rep. 2021;23(12):88.
21. Cruz J, White PC, Bell A, Coventry PA. Effect of extreme weather events on mental health: A narrative synthesis and meta-analysis for the UK. Int J Environ Res Public Health. 2020;17(22):8581.
22. Vergunst F, Berry HL. Climate change and children's mental health: A developmental perspective. Clin Psychol Sci. 2022;10(4):767-85.
23. Kolstad EW, Johansson KA. Uncertainties associated with quantifying climate change impacts on human health: a case study for diarrhea. Environ Health Perspect. 2011;119(3):299-305.
24. Philipsborn R, Ahmed SM, Brosi BJ, Levy K. Climatic drivers of diarrheagenic Escherichia coli incidence: A systematic review and meta-analysis. J Infect Dis. 2016;214(1):6-15.
25. Carlton EJ, Woster AP, DeWitt P, Goldstein RS, Levy K. A systematic review and meta-analysis of ambient temperature and diarrhoeal diseases. Int J Epidemiol. 2016;45(1):117-30.
26. Butsch C, Beckers LM, Nilson E, Frassl M, Brennholt N, Kwiatkowski R, Söder M. Health impacts of extreme weather events – Cascading risks in a changing climate. J Health Monit. 2023;8(Suppl 4):33-56.
27. Sprang G, Eslinger J, Whitt-Woosley A, Gusler S, Clemans T. Child traumatic stress and COVID-19: The impact of the pandemic on a clinical sample of children in trauma treatment. J Child Adolesc Trauma. 2023;16(3):1-12.
28. Walker S, Smith E, Bennett N, Bannister E, Narayana A, Nuckols T, Bruyere CL, Cameron L, Chapin FS, Charles S, Cour JG, Dunn RR, Francis RA, Haywood R, Lawson DF, MacDonald K, Markovic D, McNamara KE, Richards CE, Trisos CH. Defining and conceptualizing equity and justice in climate adaptation. Glob Environ Change. 2024;1:12.
29. Bolte G, Dandolo L, Gepp S, Hornberg C, Lumbi SL. Climate change and health equity: A public health perspective on climate justice. J Health Monit. 2023;8(Suppl 6):3-35.
30. Mosadeghrad AM, Isfahani P, Eslambolchi L, Zahmatkesh M, Afshari M. Strategies to strengthen a climate-resilient health system: a scoping review. Global Health. 2023;19(1):62.
31. Swain DL, Langenbrunner B, Neelin JD, Hall A. Increasing precipitation volatility in twenty-first-century California. Nat Clim Chang. 2018;8(5):427-33.
32. Egorova A, Kuhl J, Sharma R, Prabhakaran P, Kurup V, Campbell-Lendrum D, Maiero M, Neville T, Villalobos Prats E, Weil D, Wyns A, Adesanya O, Blom I, Eissa MM, Gouveia N, Gralak S, Hanna L, Joshi KV, Jung L, Alcayna T. Climate change and health research: Current trends, gaps, and perspectives for the future. Global Health J. 2021;16(3):1-14.