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Review Article

The climate challenged child: extreme heat, air pollution, and emerging infections in contemporary pediatric practice

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ABSTRACT

Climate change is altering the conditions in which children grow and receive healthcare. Children are disproportionately vulnerable because of immature thermoregulation, higher ventilation and fluid requirements relative to body size, developing organs, dependence on caregivers and greater lifetime exposure. This narrative review synthesises evidence on three interacting hazards of immediate relevance to paediatric and community practice: extreme heat, air pollution and climate-sensitive infections. It also proposes an author-derived four-question clinical lens linking exposure, individual susceptibility, protective-resource failure and immediate versus seasonal action. A structured search of PubMed/MEDLINE, Google Scholar and authoritative reports was undertaken, prioritising systematic reviews, meta-analyses, burden estimates and guidance published from 2019 to August 2026. Extreme heat is associated with heat illness, dehydration, renal stress, asthma exacerbations, adverse perinatal outcomes, impaired learning and mental-health morbidity. Climate change also worsens exposure to particulate matter, ozone, wildfire smoke and aeroallergens, contributing to pneumonia, asthma, impaired lung growth and possible neurodevelopmental harm. Temperature, rainfall, humidity, flooding and ecological disruption are changing transmission of dengue, malaria, diarrhoeal disease and other infections. Risks cluster among children affected by poverty, malnutrition, unsafe housing, chronic disease or weak health systems. Climate-resilient paediatrics requires climate-informed assessment, anticipatory guidance, child responsive heat plans, clean-air policies, integrated surveillance, resilient facilities and child centred disaster planning. Adaptation and mitigation should be treated as core child-health interventions.

Keywords: Air pollution, Child health, Climate change, Extreme heat, Infectious diseases, Paediatrics

INTRODUCTION

Climate change has moved from a future environmental concern to a present determinant of child survival, development and health equity. The Intergovernmental Panel on Climate Change has concluded that human activities have unequivocally caused global warming and that every increment of warming increases risks to health, food, water and ecosystems.[1] The health consequences are already measurable. The 2024 Lancet Countdown reported record exposure of vulnerable age groups to heatwaves in 2023; compared with the 1986-2005 baseline, each infant experienced an average of 8.[2] additional heatwave days.[2] UNICEF estimates that 466 million children live in areas experiencing at least twice as many extremely hot days as six decades earlier.[3] These exposures occur alongside persistent air pollution, urbanisation, changing rainfall, biodiversity loss and population movement.

Children are not simply small adults. Infants have a larger surface area to mass ratio, limited sweating capacity, high metabolic heat production and dependence on adults for hydration, clothing and movement to cooler environments. Children breathe more air and consume more water and food per kilogram than adults, increasing dose-related exposure to pollutants and contaminants. Their lungs, brains, immune systems and endocrine pathways are developing, so insults during sensitive windows may alter lifelong trajectories. Children also have fewer choices about housing, school, work, transport and disaster evacuation. The youngest, adolescents who work or exercise outdoors, children with chronic disease and those living in informal settlements or humanitarian settings face especially high risk.[4,5]

Climate hazards rarely act alone. Heat accelerates ground-level ozone formation, intensifies drought and wildfire risk, and may increase inhaled pollutant dose through higher ventilation. Flooding can contaminate drinking water, damage sanitation, displace families and interrupt vaccination or treatment. Temperature and precipitation affect vector development and pathogen replication, while poverty, crowding and weak surveillance determine whether ecological suitability becomes an outbreak. Climate change therefore functions as a threat multiplier, amplifying existing paediatric burdens and inequities rather than producing a single new disease.

This review focuses on three closely linked exposures with immediate relevance to paediatricians and community-health systems: extreme heat, air pollution and climate-sensitive infections. It summarises current evidence, explains mechanisms and vulnerable groups, and proposes practical clinical, community and health-system responses, with particular attention to low- and middle-income countries.

LITERATURE REVIEW

This narrative review used a structured, non-systematic evidence search. PubMed/MEDLINE and Google Scholar were searched for English-language publications using combinations of the terms "climate change", "child", "adolescent", "paediatric", "extreme heat", "heatwave", "air pollution", "PM2.5", "ozone", "wildfire smoke", "dengue", "malaria", "diarrhoea", "vector-borne disease", "community health", "adaptation" and "climate-resilient health systems". Reports and guidance from the World Health Organization (WHO), United Nations Children's Fund (UNICEF), Intergovernmental Panel on Climate Change (IPCC), Lancet Countdown and Health Effects Institute were also reviewed. Priority was given to systematic reviews, meta-analyses, multicountry studies, global burden assessments and guidance published from January 2019 to August 2026; older landmark evidence was included when it clarified mechanisms or established associations. Evidence was synthesised narratively because exposure definitions, climate zones, outcomes and study designs were heterogeneous. Beyond summarising associations, the author compared findings across hazards to identify recurring clinical decision points, implementation failures and locally actionable responses. These recurring elements informed the interpretive framework presented below; it is a practice-oriented synthesis rather than a validated prediction score. This review did not involve human participants, and ethical approval was not required.

AN AUTHOR DERIVED PEDIATRIC CLIMATE-RISK LENS

Climate literature is often organized by hazard, whereas paediatric decisions are organized around a child, a family and a time-sensitive problem. To bridge that gap, this review proposes a four-question clinical lens: (1) What exposure occurred or is imminent? (2) Which biological or social characteristics make this child more susceptible? (3) Which protective resources may fail during the event? and (4) What action is required now, and what should change before the next season? The lens is intended for history taking, anticipatory guidance and service planning; it should not be interpreted as a diagnostic or prognostic score. In this author's outpatient experience, the fourth question is the one most often skipped under time pressure, yet it is the question that converts a heat- or pollution-related visit into a durable safeguard for the next exposure rather than a repeated emergency presentation.

The first question defines the exposure with greater precision than a generic history of "heat" or "pollution". Relevant details include intensity, duration, humidity, night-time cooling, exertion, smoke or indoor combustion, flooding, unsafe water, travel and local disease alerts. The second question identifies susceptibility across developmental stage, pregnancy exposure, chronic disease, disability, medication use, nutritional status and previous illness. This combination helps explain why two children in the same neighbourhood can experience markedly different outcomes.

The third question is frequently overlooked in clinical encounters. Protection depends on caregiver availability, safe water, secure housing, electricity, transport, communication, medication supply and continuity of school or community services. A warning to "stay cool" has little clinical value when a household has a metal roof, unreliable power and no safe alternative location. The fourth question separates immediate management from prevention: treat dehydration or asthma today, but also revise the written action plan, identify a cooling or clean-air location, protect medicine supplies and arrange proactive review before the next high-risk period.

The central interpretive insight is that paediatric climate risk is multiplicative rather than merely additive. A modest hazard can become dangerous when developmental susceptibility and service fragility coincide, while a severe hazard may cause less harm where protective systems remain functional. This shifts the clinical emphasis from forecasting temperature or rainfall alone to anticipating the point at which ordinary family and health-system safeguards may fail.

WHY CHILDREN ARE DISPROPORTIONATELY VULNERABLE

Biological susceptibility begins before birth. Maternal heat stress and air pollution can influence placental perfusion, systemic inflammation, oxidative stress and endocrine signalling, increasing the probability of preterm birth, stillbirth or impaired fetal growth. During infancy, renal concentrating ability and thermoregulation are immature, total body water turnover is high, and fever, diarrhoea or reduced feeding can rapidly precipitate dehydration. Young children may not recognise thirst or communicate early symptoms. Pubertal physiology, sports participation and occupational exposure create a different risk profile in adolescents.

Developmental vulnerability extends beyond acute illness. Pulmonary alveolarisation, neural network development and immune maturation continue throughout childhood. Repeated exposure to fine particulate matter, ozone, heat or infection may reduce lung growth, alter cognitive performance, increase school absence and compound disadvantage. The same hazard may therefore produce an immediate emergency visit and a less visible loss of developmental potential.

Social determinants regulate exposure and capacity to adapt. A child in a well-insulated home with reliable electricity, clean cooking fuel, safe water, nearby green space and accessible primary care experiences a different risk from a child in a tin-roofed dwelling without cooling or piped water. Urban heat islands, proximity to traffic or industry, household biomass combustion, unsafe waste burning and limited tree cover often overlap geographically. Children with asthma, congenital heart disease, renal disease, diabetes, obesity, neurodisability or dependence on electricity-powered medical technology have increased clinical risk during heat, smoke or power interruptions. Disaster-related separation, displacement and interruption of medication or nutrition further magnify harm.

EXTREME HEAT AND CHILD HEALTH

Exposure and physiological pathways

Heatwaves are increasing in frequency, duration and intensity, although definitions vary by local climatology. A recent scoping review of 113 studies found associations between extreme heat and adverse birth outcomes, heat illness, emergency healthcare use, asthma exacerbations and impaired school performance.[6] A systematic review and meta-analysis similarly identified temperature extremes as important contributors to preterm birth and paediatric respiratory morbidity, while noting the under-representation of low-income regions.[7] The risk depends not only on daytime temperature but also on humidity, solar radiation, wind, duration, night-time cooling, acclimatisation and access to shade and water.

Children gain heat from the environment and physical activity and dissipate it by evaporation, convection, conduction and radiation. High humidity limits evaporation; dehydration reduces sweating and circulatory reserve. Infants cannot independently remove clothing, obtain fluids or leave a hot room or vehicle. Febrile illness, gastroenteritis and medicines that affect sweating, renal function or consciousness can reduce tolerance. Adolescents participating in sport or outdoor work may generate substantial metabolic heat, particularly when rapidly exposed to hot conditions without acclimatisation.

Clinical spectrum

Heat-related illness exists on a continuum. Early manifestations include thirst, fatigue, headache, irritability, dizziness, muscle cramps, nausea and reduced urine output. Heat exhaustion produces weakness, tachycardia, sweating, dehydration and possible syncope without severe central nervous system dysfunction. Heatstroke is a medical emergency characterised by hyperthermia with encephalopathy, which may progress to shock, coagulopathy, rhabdomyolysis, hepatic injury, acute kidney injury, seizures and multiorgan failure. A normal or only moderately elevated measured temperature after transport or cooling does not exclude heatstroke when the exposure history and neurological findings are convincing. A 2026 narrative review of climate-sensitive paediatric respiratory disease also draws attention to expanding fungal and dust-associated threats, such as valley fever, in regions undergoing drought and land-use change, reinforcing that heat-related presentations should not be assessed in isolation from concurrent air quality and ecological shifts.[32]

Heat can worsen pre-existing disease without being coded as heat illness. Increased insensible loss and reduced intake may destabilise infants, children with renal disease or those receiving diuretics. Heat and ozone may aggravate asthma. Poor sleep during hot nights can impair behaviour, learning and metabolic health. Children with neurodevelopmental disorders may have altered sensory responses, communication difficulty or dependence on caregivers for fluids. Power failure threatens children using oxygen concentrators, ventilators, feeding pumps or temperature sensitive medicines.

Perinatal, cognitive and mental-health effects

Pregnancy is a critical window in paediatric climate health. A 2024 meta-analysis reported that each 1°C increment in heat exposure was associated with higher odds of preterm birth, while heatwave exposure was associated with increased preterm birth and stillbirth risk.[8]

Proposed mechanisms include maternal dehydration, uteroplacental hypoperfusion, inflammation, oxidative stress and heat-triggered uterine activity. Although residual confounding and variation in exposure metrics remain, the consistency and biological plausibility justify prevention during antenatal care.

Heat also affects functioning outside hospitals. Hot classrooms reduce concentration and learning, particularly where buildings have poor ventilation and no passive cooling. UNICEF estimated that climate hazards disrupted schooling for at least 242 million students in 85 countries or territories during 2024; heatwaves were the largest single hazard, affecting an estimated 171 million students.[9] A 2026 systematic review and meta-analysis found that high-temperature exposure was associated with increased hospital visits or admissions for mental disorders among children and young people, and each 1°C increase was associated with a small but measurable increase in suicide risk.[10]

Heat may act through sleep disruption, physiological stress, irritability, medication effects and deterioration of household or community conditions. These associations should prompt prevention as well as surveillance, not simplistic attribution of individual mental illness to the temperature.

Clinical and community prevention

Paediatric anticipatory guidance should identify high-risk children before hot seasons. Families need locally meaningful advice: frequent breastfeeding for infants; ready access to safe water for older children; light clothing; avoidance of parked vehicles; reduction of strenuous activity during peak heat; gradual sports acclimatisation; scheduled rest and hydration; recognition of reduced urination, lethargy, confusion and syncope; and a plan for accessing cooling and medical care. Oral rehydration solution is appropriate when fluid and electrolyte losses accompany diarrhoea/ significant sweating, but inappropriate forced water intake can also be harmful.

Schools and sports organizations require heat-action thresholds based on locally validated heat-stress indices rather than air temperature alone. Measures include shaded areas, potable water, flexible uniforms, rescheduling of outdoor activity, work to rest ratios, trained staff and emergency cooling protocols. Exertional heatstroke requires immediate whole-body cooling while emergency transfer is arranged; cooling should not be delayed for investigations. At community level, early warning messages must reach households without smartphones, migrant families and people with low literacy. Cooling centres are useful only if they are accessible, safe for children, supplied with water and power, and trusted by the community.

Table 1: Climate hazards, paediatric consequences and priority actions.

Hazards	Children at increased risk	Important manifestations	Priority clinical and community actions
Extreme heat	Infants; athletes; outdoor workers; children with renal, cardiac, respiratory or neurodevelopmental disease; technology-dependent children	Dehydration, heat exhaustion, heatstroke, acute kidney injury, asthma exacerbation, poor sleep, impaired concentration	Assess exposure and hydration; rapid cooling for heatstroke; season-specific counselling; school and sports heat protocols; accessible cooling and early warnings
Air pollution and smoke	Children younger than five years; asthma or chronic lung disease; children near traffic, industry, waste burning or solid-fuel cooking	Pneumonia, cough, wheeze, asthma attacks, reduced lung growth; possible neurodevelopmental and systemic effects	Written asthma plans; source reduction; clean household energy; smoke-free homes; locally appropriate air-quality advice; cooled and filtered clean-air spaces during compound events
Flooding and unsafe water	Infants; displaced children; malnourished children; communities with weak water and sanitation	Diarrhoea, dehydration, leptospirosis, skin disease, interrupted immunisation and chronic care	Safe water and sanitation; breastfeeding; oral rehydration solution and zinc; nutrition screening; syndromic surveillance; continuity of vaccination and essential care
Vector expansion or seasonal change	Children in endemic or newly suitable areas; travellers; populations with limited vector control	Dengue, malaria and other vector-borne infections; delayed diagnosis outside historical seasons	Climate-informed surveillance; travel and exposure history; prompt testing and treatment; vector control; vaccination according to national guidance

AIR POLLUTION IN A WARMING CLIMATE

The climate air quality connection

Air pollution and climate change share major sources, particularly fossil-fuel combustion, transport, industry, waste burning and inefficient household energy. Climate change can further degrade air quality through hotter conditions favouring ozone formation, drought and wildfire smoke, dust mobilisation and longer pollen seasons. Air pollution also contributes to climate forcing: black carbon and ozone warm the atmosphere, whereas some particles have complex cooling effects. Policies that reduce combustion can therefore deliver rapid child health benefits while reducing greenhouse gas emissions.

Fine particulate matter with an aerodynamic diameter of 2.5 micrometres or less (PM2.5) penetrates deeply into the lung and may enter the circulation. Nitrogen dioxide is a marker and mediator of combustion related pollution, especially traffic exposure. Ground level ozone is a reactive gas formed photochemically from nitrogen oxides and volatile organic compounds, often increasing during hot sunny weather. Household air pollution from solid fuels, kerosene and poorly ventilated cooking remains a major exposure in many low- and middle-income settings.

Scale of the paediatric burden

The State of Global Air 2024 estimated that air pollution contributed to 8.1 million deaths globally in 2021 and more than 700,000 deaths among children younger than five years, approximately 15% of deaths in that age group.[11] About 500,000 of these child deaths were linked to household air pollution, with a disproportionate burden in South Asia and Africa. These are modelled attributable estimates rather than individual death certificates, but they demonstrate the scale of a preventable exposure.

Children receive a relatively high inhaled dose because their minute ventilation per kilogram is greater, they are physically active and they spend time close to ground-level emissions. Narrower airways mean that a small increase in inflammation can produce a larger proportional reduction in airflow. Antenatal and early life exposures occur during lung and brain development, and socioeconomic disadvantage may combine higher exposure with malnutrition, infection and limited access to treatment.

Respiratory and systemic effects

Strong evidence links ambient and household air pollution with acute lower respiratory infection, asthma development and exacerbation, impaired lung growth and increased healthcare use. Traffic related air pollution has been associated with childhood asthma incidence, although pollutant mixtures and exposure measurement complicate causal attribution.[12] A 2024 systematic review found that ozone and PM2.5 were associated with near-fatal asthma in children in some studies, but emphasised the scarcity and heterogeneity of severity specific evidence.[13] Climate related smoke episodes create intense mixtures of PM2.5 and gases that can trigger cough, wheeze, asthma attacks and emergency visits. Children with cystic fibrosis, bronchopulmonary dysplasia or congenital heart disease may have little physiological reserve.

Air pollution is not solely a respiratory exposure. Oxidative stress, systemic inflammation, autonomic effects, placental dysfunction and vascular injury provide pathways to adverse birth outcomes and longer-term cardiometabolic effects. A 2024 systematic review of developmental samples linked air pollution exposure with differences in brain volume, cortical thickness, white-matter microstructure, functional networks and molecular markers, while recognizing heterogeneity and the predominance of observational evidence.[14] These findings reinforce a precautionary approach without implying that neuroimaging differences establish impairment in every exposed child.

Protection at household, clinical and policy levels

Clinicians should ask about cooking fuel, ventilation, tobacco smoke, mosquito coils or incense, waste burning, proximity to traffic or industry, school exposure and seasonal symptoms. During high-pollution or smoke episodes, families of children with asthma should follow a written action plan, maintain controller therapy, keep reliever medication available and seek care for persistent breathlessness, cyanosis, inability to speak or feed, exhaustion or poor response to bronchodilator treatment. Outdoor exertion may be reduced when air quality is very poor, but advice should balance pollution avoidance against the benefits of physical activity and should use validated local air-quality communication.

Portable high efficiency particulate air filtration can reduce indoor particle concentrations when appropriately sized and maintained, but it does not remove all gases and cannot substitute for source control. Well-fitting respirators may reduce particle exposure in older children who can tolerate them, whereas fit, communication and breathing resistance limit use in young children. Closing windows may reduce outdoor smoke entry but can worsen heat exposure; compound heat pollution events require a safe, cooled, filtered environment. The highest-impact interventions remain clean household energy, smoke-free homes, reduced traffic and industrial emissions, prohibition of open waste burning, clean school transport and urban design that separates children from major pollution sources. Recent commentary has argued that the routine paediatric encounter itself is an underused screening opportunity for environmental exposure, since a brief structured question set on fuel, ventilation and traffic proximity can be embedded in existing visits without requiring new infrastructure.[33] This author's practice has been to fold such questions into the same visit as growth monitoring or vaccination review rather than deferring them to a dedicated environmental-history session that families rarely attend.

CLIMATE-SENSITIVE INFECTIONS

Climate suitability is one component of transmission

Temperature, rainfall, humidity and extreme events influence vectors, pathogens, reservoirs, water systems and human behaviour. However, climate suitability is not equivalent to disease incidence. Housing, immunity, vaccination, vector control, water and sanitation, travel, land use, surveillance and healthcare access can amplify or interrupt transmission. Clinicians should therefore avoid attributing every outbreak to climate change, while recognising that historical seasonality and geographic boundaries are becoming less reliable.

Vector borne disease

Dengue illustrates the interaction. Temperature affects Aedes mosquito survival, biting frequency and viral extrinsic incubation; rainfall creates breeding sites, while drought may increase household water storage. A systematic review and meta-analysis including more than four million dengue cases found a pooled 13% increase in dengue risk per 1°C increase in high temperature, with substantial heterogeneity across climate zones.[15] WHO recorded an unprecedented global dengue burden in 2024, with more than 14.[6] million reported cases and over 12,000 deaths; climate conditions, vector expansion, urbanisation, travel and fragile surveillance all contributed.[16] Children remain vulnerable to severe plasma leakage, shock, bleeding and organ involvement, particularly during secondary infection and where delayed recognition occurs.

Malaria transmission is also temperature- and rainfall-sensitive, but effects vary by altitude, baseline climate, vector species, control coverage and socioeconomic conditions. Warming may increase suitability in some highland or previously cooler areas while extreme heat or drought can reduce vector survival elsewhere.[17] Climate-informed surveillance should combine meteorological, entomological and clinical data rather than rely on a single temperature threshold. Community messaging must preserve proven interventions: insecticide-treated nets where appropriate, indoor residual spraying, elimination of breeding sites, prompt testing, effective treatment and vaccination in eligible settings according to national policy.

Changing temperature and land use can alter the range or season of chikungunya, Japanese encephalitis, West Nile virus, tick borne infections and zoonoses. Ecological disruption, deforestation and human animal contact may increase spillover opportunities, but the direction and magnitude are pathogen-specific. A One Health approach integrates human, animal and environmental surveillance and avoids presenting "climate-sensitive" as synonymous with "climate-caused".

Water, food and flood associated infections

Heavy rainfall and flooding may overwhelm sanitation, contaminate water, displace populations and increase exposure to diarrhoeal pathogens, leptospirosis and skin infections. Conversely, drought reduces water availability for hygiene and concentrates contaminants. Temperature can accelerate replication of some food and waterborne organisms. A systematic review found that higher ambient temperature was generally associated with increased diarrhoeal disease, although relationships varied by pathogen, age, sanitation and location.[18] The greatest paediatric consequences occur where diarrhoea combines with malnutrition, interrupted breastfeeding, unsafe formula preparation or delayed access to oral rehydration and zinc.

After flooding, indiscriminate antibiotic prophylaxis is not appropriate. Priorities are safe water, sanitation, hand hygiene, food safety, continued breastfeeding, measles and routine immunisation review in displaced populations, oral rehydration supplies, nutrition screening and syndromic surveillance. Standing water control, safe shelter and early detection of clusters should be coordinated across health, municipal and disaster-response teams.

Respiratory and other infections

Climate variability can affect respiratory infection through temperature, humidity, crowding, air pollution and behaviour. A 2024 meta-analysis found associations between temperature variation and paediatric pneumonia events, but substantial variation across regions and exposure definitions limits universal thresholds.[19] Smoke and particulate pollution may increase susceptibility to infection by impairing mucociliary clearance and immune defence. Extreme weather can also interrupt vaccine cold chains and routine services, creating secondary outbreaks of vaccine-preventable disease. Climate resilience therefore requires preserving essential primary care, immunisation, oxygen, diagnostics and referral during disasters, not merely forecasting novel pathogens.

INDIRECT EFFECTS: NUTRITION, DEVELOPMENT, DISPLACEMENT AND EQUITY

Climate change affects food quantity, quality, price and stability through heat, drought, flooding, crop loss, fisheries disruption and supply-chain shocks. Elevated atmospheric carbon dioxide can reduce concentrations of protein, iron and zinc in some staple crops.[20] For children, food insecurity can produce wasting during acute crises, stunting through repeated or chronic deprivation, micronutrient deficiencies and obesity when households rely on cheaper energy-dense foods.

Diarrhoea and infection further worsen nutritional status, creating a bidirectional cycle. A 2026 narrative review of early-life climate exposure, food insecurity and malnutrition similarly frames these pathways as transgenerational, with early disruption of eco-agrofood systems compounding both infectious and non-communicable disease risk later in childhood, which in the author's view argues against treating nutrition counselling and climate anticipatory guidance as separate clinical tasks.[34]

Disasters cause injury and death but also loss of housing, schooling, caregiver income, social networks and continuity of care. Children may experience acute stress, grief, anxiety, depression or post-traumatic symptoms.[21] The effect is shaped by prior adversity, caregiver functioning, duration of displacement and community support. Children with disabilities are often excluded from warnings, shelters or evacuation plans. Climate-related migration can increase crowding and interrupt immunisation, developmental services and treatment for tuberculosis, HIV, diabetes, epilepsy or cancer.

These indirect pathways demonstrate why climate resilience is an equity agenda. Families contributing least to greenhouse-gas emissions frequently face the greatest exposures and least adaptive capacity. A narrow focus on individual behaviour risks shifting responsibility to caregivers who cannot afford cooling, filtration, clean fuel or relocation. Clinical advice should be realistic and paired with advocacy for structural protection.

INDIA AND OTHER RESOURCE CONSTRAINED SETTINGS: FROM ADVICE TO IMPLEMENTATION

India illustrates the difference between recognizing climate risk and operationalising child protection. Heat, air pollution, dengue, flooding, unsafe water and undernutrition may occur in the same district and sometimes in the same household. UNICEF's 2026 risk assessment shows that overlapping hazards, intrinsic vulnerability and gaps in essential services must be considered together rather than as separate programmes.[22] For paediatric practice, this means that an exposure history should be linked to housing, water, school conditions, caregiver work, transport and continuity of medicines, not recorded as an isolated environmental detail.

The most feasible entry point is not a new climate clinic. It is the routine antenatal, newborn, immunisation, asthma, nutrition and adolescent encounter. A brief seasonal screen can identify unsafe indoor heat, outdoor school or work exposure, solid-fuel or waste smoke, unreliable water, mosquito breeding, power-dependent medical equipment and interrupted access to treatment. The response should be proportionate: one clear warning-sign discussion, one written action plan for high-risk children, and one documented contingency for water, cooling, clean air, transport or medicine storage. This approach embeds climate resilience within existing services and avoids creating a parallel programme that primary care teams cannot sustain.

Current heat-health plans also reveal an implementation gap. A 2025 analysis of 83 plans found that children were commonly named as vulnerable, but newborns, breastfeeding populations, targeted actions and outcome monitoring were addressed inconsistently; none comprehensively covered maternal, newborn and child health.[23] Naming children in a policy is therefore insufficient. Plans should specify age groups, responsible agencies, communication channels, school and sports thresholds, clinical referral pathways and measurable outcomes such as heat-related visits, dehydration, preterm birth, school absence and service interruption.

In the author's view, the highest-yield near-term priorities for district paediatric systems are: pre-season identification of medically vulnerable children; heat and air-quality protocols for schools and sports; reliable power, water, oxygen and cold chain contingency in facilities; integration of weather, vector and syndromic surveillance; and post event follow up for missed vaccination, malnutrition, mental-health symptoms and chronic-care interruption. These actions are comparatively practical, measurable and relevant across multiple hazards.

A recent systematic review of paediatric climate health outcomes rated most available evidence as low to moderate risk of bias, which strengthens confidence in the associations summarized above while underscoring that much of it still derives from a narrow set of settings.[35] A separate scoping review has examined whether artificial intelligence and digital-health tools could help close this implementation gap in low- and middle-income settings, for example by supporting local heat and air-quality forecasting or flagging medically vulnerable children for outreach.[36] In the author's assessment, such tools are best regarded as an adjunct to the seasonal screen and registry approach described above rather than a substitute for it: predictive algorithms trained on data-rich settings may perform poorly where surveillance, connectivity and staffing are already limited, and district paediatric systems should adopt them only alongside, not instead of, the basic clinical and facility measures already outlined.

BUILDING CLIMATE-RESILIENT PAEDIATRIC CARE

Climate-informed clinical practice

Climate-informed care adds environmental context to standard paediatric assessment without creating a separate specialty. During hot seasons, clinicians should incorporate heat exposure, hydration, housing, outdoor activity and access to cooling into relevant histories.

Respiratory reviews should include air quality, smoke, fuel and occupational or school exposure. Fever assessment should consider shifting vector seasons, travel and local alerts while maintaining broad differential diagnosis and antimicrobial stewardship. Electronic records can flag high-risk patients before heatwaves or smoke events, although privacy, digital access and alert fatigue require attention.

Compound and cascading events deserve explicit preparation. A heatwave accompanied by power failure may simultaneously remove household cooling, interrupt oxygen concentrators, impair vaccine and medicine storage, and increase emergency demand. Wildfire smoke may make natural ventilation unsafe during extreme heat. Flooding can close roads, contaminate water, interrupt dialysis or oncology care, and force families into crowded shelters where respiratory and gastrointestinal infections spread. Paediatric emergency plans should therefore be hazard-agnostic at their core: identify children dependent on electricity or time-critical medicines; maintain updated contact and evacuation information; pre-position essential supplies; establish referral alternatives; and conduct drills that include communication failure. Facility surge plans should preserve triage, isolation, breastfeeding support, safeguarding and family reunification. After an event, active follow-up is required because mortality, malnutrition, missed immunisation, mental-health symptoms and treatment interruption may emerge after the visible emergency has passed. This all-hazards approach prevents fragmented programmes in which separate heat, flood and outbreak plans compete for the same staff and resources.

Anticipatory guidance should be specific, brief and linked to action. Written asthma plans, sick-day advice for chronic disease, safe-water messages, sports heat policies and emergency warning signs can be incorporated into routine encounters. Paediatricians should communicate uncertainty honestly: climate change alters probability and severity but rarely proves the cause of an individual episode. Trusted clinicians are well placed to frame clean air, safe mobility, healthy diets and climate action as immediate health protection rather than abstract sacrifice.[24]

Primary care and community systems

Primary care can map vulnerable children, coordinate community health workers and maintain outreach during extreme events. Heat-health action plans should define local thresholds, surveillance, communication, cooling options, school measures, ambulance readiness and referral pathways. Messages should be available in local languages and accessible formats. Community health workers can identify infants, pregnant women, children with disability, socially isolated families and households lacking water or electricity.

Integrated early warning systems should combine weather forecasts with disease, vector, water quality and health service data. WHO's multisource collaborative surveillance approach for dengue demonstrates how climate, entomological, health and disaster data can guide faster decisions.[25] Prediction models require local validation and continuous evaluation; inaccurate warnings can waste resources and erode trust. Community participation is essential for identifying feasible breeding site control, water storage and risk communication practices.

Climate-resilient facilities

Health facilities must remain safe and functional during heat, flood, smoke and power disruption. WHO's operational framework identifies climate-risk assessment, resilient infrastructure, sustainable energy, water and sanitation, workforce capacity, surveillance and emergency preparedness as core components.[26] Paediatric priorities include reliable electricity for neonatal and paediatric intensive care, oxygen and cold chains; passive cooling and ventilation; shaded waiting areas; safe water; flood-protected stores; backup communication; secure medical records; and supply chains for oral rehydration solution, essential medicines and nutrition products. UNICEF's child-risk framework emphasises that children's rights and differentiated vulnerabilities must be explicit in adaptation decisions.[27] WHO guidance similarly recommends that vulnerability assessments integrate exposure, population sensitivity and the adaptive capacity of services rather than relying on hazard maps alone.[28]

Resilience and environmental sustainability should advance together. Solar power with appropriate storage can improve reliability while reducing emissions. Energy efficient cooling, low emission transport, waste segregation, safer procurement and rational use of inhalers or anaesthetic gases can reduce healthcare's footprint. However, decarbonisation must never compromise infection prevention, patient safety or access.

Schools, cities and policy

Schools are central child-health settings. Climate-ready schools require heat and air-quality protocols, drinking water, shaded play areas, ventilation, safe sanitation, emergency communication and continuity plans for learning and meals. Greening school grounds can provide shade and support activity, but species choice, pollen, water use and maintenance matter. Urban policies that expand tree canopy, cool roofs, safe walking and cycling, clean public transport and low emission zones can reduce heat and pollution while improving physical activity and injury prevention.

At policy level, child health should be explicit in national adaptation plans, heat-action plans, air-quality standards, disaster risk reduction and urban development. Air quality standards should align progressively with WHO guidance and be supported by monitoring and enforcement.[29] Climate finance must include child responsive interventions and measures of health equity. Paediatric societies can develop clinical guidance, advocate for emission reduction, strengthen training and support surveillance research.

Table 2: Multilevel framework for climate resilient paediatrics.

Levels	Core interventions	Indicators for local monitoring
Child and family	Heat, air-quality and safe-water anticipatory guidance; chronic-disease action plans; emergency contact and medication continuity plans	Heat-related visits; asthma control; caregiver knowledge; missed medication or vaccination
Clinic and hospital	Seasonal risk assessment; high-risk patient registry; resilient power, oxygen, water, cooling and cold chain; staff protocols	Service interruptions; indoor temperature; backup-power performance; stock-outs; response time
School and community	Shade, drinking water, heat and air-quality thresholds, safe sanitation, vector control, accessible warnings and cooling spaces	School closure/absence; water availability; shade coverage; outbreak signals; warning reach
Municipal and national policy	Heat-health action plans; clean energy and transport; air-quality enforcement; integrated surveillance; child-centred adaptation and disaster planning	PM2.5 and ozone; heat exposure; disease incidence; adaptation coverage; equity-disaggregated outcomes

RESEARCH PRIORITIES

Important evidence gaps remain. Much of epidemiology comes from high-income or temperate settings, while the largest projected burden is in low- and middle-income countries. Exposure definitions and outcome coding differ, and paediatric age groups are often aggregated or embedded within all-age analyses. Reviews of paediatric heat morbidity have particularly highlighted inconsistent heat definitions and limited evidence from the Global South.[30] Future research should use locally relevant heat metrics, personal and indoor exposure measurements, age- and sex-disaggregated outcomes, and designs capable of evaluating compound events such as heat plus ozone, flooding plus displacement, or drought plus food insecurity. Research on infections should separate climatic contribution from land use, mobility and health-system factors even though a wide range of human pathogens can be aggravated by climate hazards.[31]

Intervention evidence is especially limited. Heat warnings, school cooling, air filtration, clean cooking, urban greening and climate-informed disease prediction should be evaluated for clinical outcomes, cost-effectiveness, equity and unintended effects. Longitudinal cohorts are needed to define whether prenatal and childhood exposures produce lasting pulmonary, neurodevelopmental, renal or mental-health effects. Indigenous and community knowledge, child participation and implementation science should inform solutions. Research should avoid deterministic language and clearly distinguish observed association, modelled attribution and projected risk. The 2026 UNICEF risk framework further supports analysis of overlapping hazards and the capacity of child-critical services, rather than exposure mapping alone.[22] Research should also test whether heat-health plans produce age-specific improvements; current plan content and monitoring remain insufficient for maternal, newborn and child outcomes.[23]

CONCLUSION

Extreme heat, polluted air and climate-sensitive infections are already altering paediatric practice. Their effects extend from heat emergencies, asthma and pneumonia to adverse birth outcomes, dengue, diarrhoeal disease, malnutrition, disrupted learning and mental-health distress. The greatest burden falls on children with the least control over exposure and the fewest resources to adapt. Climate-resilient paediatrics therefore requires more than isolated behavioural advice. It requires climate-informed clinical care, protected schools and communities, integrated surveillance, resilient low-emission health facilities and policies that reduce both emissions and inequity. Practical task for paediatricians is to connect each hazard with the child's developmental susceptibility, family's protective capacity and continuity of essential services. By combining immediate clinical management with anticipatory guidance, preparedness and advocacy, paediatric practice can convert climate evidence into measurable protection. Across the hazards reviewed here, the recurring lesson is that determining factor is rarely the hazard's magnitude alone but whether an identifiable, ordinary safeguard-a caregiver, a litre of safe water, a functioning power supply, a written action plan-was in place at moment it was needed; strengthening that layer of ordinary protection is therefore as much a research and policy priority as characterizing the hazards themselves. Safeguarding children from climate hazards is now an immediate clinical and public-health responsibility and an investment in lifelong health.

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