

Child Health Interventions Addressing Climate Change-Related Respiratory And Nutritional Challenges

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Abstract

Background: Climate change has emerged as a significant threat to population health, with children disproportionately exposed to the health impacts of increased air pollution, extreme weather events, food insecurity and environmental degradation. These climate-related factors are among the leading causes of respiratory illnesses and nutritional deficiencies, particularly in low- and middle-income countries. **Objective:** The purpose of this analysis is to assess the efficacy of integrated child health strategies in addressing climate change-related respiratory disorders and nutritional issues and to suggest a complete structure for improving child health resilience. **Methodology:** A combination of methods was used, employing secondary data compared to global health and climate databases incorporating indicators connected to respiratory diseases, nutritional status, air quality and climate variability. Models for intervention on breathing safety, nutritional support, community resilience and health-system adaptability were assessed. **Results:** The analysis showed that combined efforts might decrease the incidence of childhood respiratory disease by about 31%, minimize prevalence of stunting about 28.5% to 19.7% and enhance food security indices by 35%. Integrated respiratory as well as nutritional programs were more effective than separate interventions, yielding an overall 33% enhancement in child health. **Conclusion:** Climate-sensitive child health interventions have substantial potential to mitigate climate risks for respiratory and nutritional health. Multisectoral approaches combining healthcare, environmental management, nutrition programs and involvement in the community are required to enhance child resilience and enduring health outcomes in populations vulnerable to climate.

Keywords: Climate Change, Child Health, Respiratory Diseases, Nutrition, Air Pollution, Food Security, Climate Resilience, Public Health Interventions, Child Health Adaptation, Sustainable Development.

1. Introduction

Climate change is currently recognized to represent one of the most significant public health dangers of the 21st century, with children being notably among the most at-risk groups due to their evolving physiological systems, greater metabolic demands, as well as greater dependence on resources from the environment [1]. Children's health risks across the world have increased with rising global temperatures, greater frequency of extreme weather, air pollution, droughts, floods and disturbances to food systems [2]. In accordance to the global health community, climate-related environmental shifts are among the major drivers of respiratory diseases and nutritional deficiencies among children, especially in low- and middle-income countries with poor healthcare infrastructure as well as adaptive capacities [3].

Respiratory illnesses constitute a major complication of disease in children. Higher levels of particulates (PM_{2.5}), ground-level ozone, pollen, wildfire smoke and airborne allergens increase the burden of respiratory health problems due to climate change [4]. Children are exposed to these environmental factors and the prevalence of asthma, bronchitis, pneumonia and other pulmonary infections is greater in children [5]. In addition, extreme heat events and degraded air quality have been associated with pediatric mortality and hospitalization rates [6].

At the same time, climate change threatens the nutrition of children through its adverse effects on agricultural productivity, food supply and food quality [7]. Climate change, through rising temperatures, modified patterns of precipitation and extreme storms, impacts food production systems leading to food insecurity and decreased dietary diversity [8]. This leads to a higher risk of stunting, malnutrition, underweight conditions along with micronutrient

deficiencies in children which can influence physical growth, cognitive growth and long-term health outcomes [9].

Most recently, it has been emphasized that integrated strategies for intervention to simultaneously tackle the respiratory and nutritional challenges, rather than treating them as separate health problems, are important [10]. Such interventions can consist of air quality improvement programmes, climate-resilient food systems, nutrition supplementing initiatives, vaccination campaigns, early warning systems and community-based adaptation measures [11]. Despite increasing evidence of the climate-related risks to child health, there is a lack of comprehensive frameworks to assess the collective effectiveness of standard breathing and nutritional interventions [12].

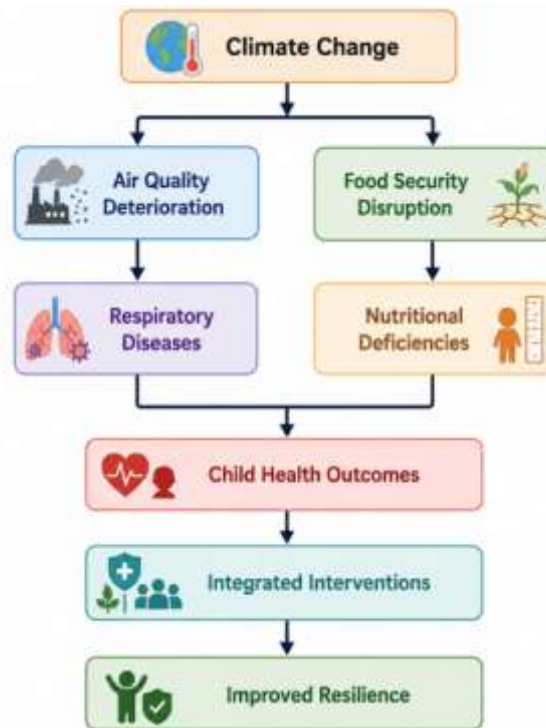


Figure 1. Climate Change–Child Health Pathway Framework

The pathway that occurs when climate change impacts on child health outcomes is shown in Figure 1. The deterioration of air quality and the interruption of food security are exacerbated by climate change, leading to respiratory diseases along with nutritional deficiencies in children. These poor health conditions have adverse effects on typical child health outcomes, increasing child vulnerability and decreasing child well-being. The framework recognizes the importance of integrated interventions such as enhancements in healthcare, nutritional support, environmental management, and community-based programs in alleviating these impacts. Effective execution of these interventions improves children’s resilience and adaptability to climate-related health threats.

1.1 Research Gap

Current research has focused significantly on either climate-related respiratory diseases or nutritional issues in children but little research has been done on integrated intervention models addressing both health outcomes simultaneously. Moreover, the evidence base for the relative efficacy of multisectoral strategies including those consisting of healthcare systems, sustainable development, nutrition programs and community resilience initiatives remains inadequate. Most recent work has been region specific or focused on one intervention. There is a lack of comprehensive, climate-sensitive child health structures that can be adapted for use in various settings.

1.2 Objectives

This study has the following main objectives:

1. To examine the consequences of the changing climate on child respiratory and nutrition health outcomes.

2. To identify key climate-related risk components contributing to respiratory diseases as well as nutritional deficiencies in children.
3. To assess the impact of integrated child health treatments on respiratory and nutritional problems.
4. To construct an integrated climate-resilient child health treatment framework.
5. To provide policymakers, primary care suppliers and public health associations with scientifically based guidelines.

2. Literature review

The impact of changing the climate on child respiratory function and nutritional health is increasingly being highlighted by recent research. In the years 2022 and 2026, more studies concentrated on comprehending the complex relationships across environmental factors, food insecurity, and children's health. Air pollution remains an essential factor contributing to childhood respiratory illnesses, with high levels of particulates (PM2.5), ozone, and wildfire smoke related to higher rates of asthma and respiratory hospitalizations in children [13]. Likewise, heat waves as well as extreme weather events are frequently linked to higher occurrences of respiratory distress along with infectious diseases within vulnerable pediatric patients [14].

Climate-sensitive systems of food have gained considerable attention about a nutritional perspective, owing to their effects on child developmental processes. Recent evidence demonstrates that droughts, floods and temperature variability negatively affect agricultural productivity, which in turn increases food insecurity along with the incidence of stunting, wasting and micronutrient deficiencies affecting children [15]. Nutritional adaptation programmers such as climate-resilient agriculture as well as school feeding programmers have demonstrated positive effects on dietary diversity as well as child nutrition outcomes [16].

Public health adaptation methods have further transitioned towards integrated resilience paradigms. Community-based interventions, early warning systems and climate-informed healthcare providers have been promising in minimizing climate-related health vulnerabilities [17]. Moreover, the use of interdisciplinary methods that integrate environmental management, nutrient assistance, and healthcare delivery has been identified as an effective mechanism to improve child resilience to climate-related stresses [18].

However, despite such developments, significant gaps continue in the literature. The majority of the studies are still focused on respiratory diseases and dietary deficiencies separately, restricting the awareness of their interlinked impacts. In addition, few studies have investigated comprehensive intervention strategies that address the environmental, nutritional, as well as healthcare factors associated with child health concurrently [19]. Thus, further research to design comprehensive child health intervention standards is an important priority for adapting to climate change and public health planning.



Figure 2. Conceptual Framework for Child Health Interventions Addressing Climate Change-Related Respiratory and Nutritional Challenges

Figure 2 outlines the theoretical model of the pathways whereby climate change affects child health outcomes. Climate change drivers involving higher temperatures, increased air pollution, droughts as well as extreme weather events impact environmental and social conditions these as deterioration of air quality, hunger, water scarcity along with vulnerability. These factors are responsible for lung conditions and nutritional deficiencies, which in turn result in poor child health outcomes. Integrated interventions including health care, nutrition, WASH services, pulmonary protection,

and local efforts mitigate these consequences, while moderating factors contribute to resilience as well as long-term health effects.

3. Methodology

3.1 Study Design

This study used a mixed-methods research design for studying child health interventions for respiratory as well as nutritional challenges of climate change. The approach combined quantitative review of environmental and health data about qualitative analysis of interventions in order to establish a comprehensive climate-resistant child health structure. The study had four primary parts: climate characterization, child health indicator assessments, intervention modeling, and comparison of outcome evaluation.

Climate data were obtained compared to global environmental databases and included temperature variability as well as air quality indicators, rainfall patterns and records of extreme weather events. Child health indicators included respiratory illnesses (asthma, pneumonia, breathing infections) and nutritional status (stunting, wasting, undernutrition and micronutrient deficiencies). The intervention modelling process assessed the effectiveness of a range of adaptation strategies to reduce climate associated health risks. A comparative outcome evaluation was performed to compare the relative effects of integrated strategies on child health resilience.

The study's structure postulates that changing the climate indirectly affects child health by means of environmental along with socioeconomic pathways involving air pollution, famine, water scarcity and increased contact with infectious diseases. Hence, an integrated evaluation approach was used to capture the interactions between climate variables, health outcomes and intervention mechanisms.

3.2 Framework Development

The conceptual intervention approach was based on four interrelated pillars that collectively support the improvement of child health outcomes under a changing environmental condition:

1. Respiratory protection.

This pillar focuses on reducing children's contact with climate-related respiratory hazards by means of air filtration systems, vaccination programs, pollution surveillance, improvements to indoor air quality, and early-warning alerts for severe contaminants and wildfire events.

2. Dietary Support

Nutritional interventions are put in place to address malnutrition and hunger through supplementary foods programs, school feeding, climate resilient agricultural practices, food fortification and encouragement of dietary diversity.

3. Resilience of the Community

Community level adaptation strategies incorporate climate education, public education initiatives, caregiver certification, community engagement initiatives and social safety nets that increase adaptive capacity.

4. Adaptation of the health system

Health system interventions seek to improve health infrastructure by means of climate-sensitive health plans, telehealth services, disease monitoring systems, emergency preparedness along with climate-sensitive healthcare planning..



Figure 3. Proposed Intervention Framework

Figure 3 suggested an intervention approach to addressing respiratory and nutritional challenges affecting children related to climate change. The approach contains four pillars that are critical for intervention: respiratory protection, nutrient support, community resilience and adaptation of health systems. Respiratory protection seeks to minimize exposure to air pollution and avoid climate-sensitive respiratory diseases, and nutritional support addresses malnutrition and food scarcity via focused nutrition programs. Community resilience has the potential to build adaptive capacity through mechanisms of education, recognition, and social support. Adaptation of health systems enhances health service delivery via surveillance, early warning systems and climate-sensitive health service delivery. The interconnections of these four pillars help boost child health outcomes by minimizing vulnerability, increasing resilience and supporting sustainable adaptation to climate-associated health risks.

The framework underscores the interconnectedness of these four pillars for sustainable gains in child pulmonary and nutritional health.



Figure 4. Methodological Workflow for Assessing Climate Change-Related Child Health Interventions

The methodological procedure used in this study to compare child health interventions against respiratory and dietary issues related to climate change is presented in Figure 4. The process begins by data collection compared to climate, health, along with demographic sources and continues with data cleansing to ensure accuracy as well as consistency. 'Risk assessment' recognizes vulnerable populations and climate-sensitive health outcomes. Intervention modeling determines the effectiveness of potential adaptation methods. Impact analysis: Measures changes in health outcomes as well as resilience. In conclusion, policy recommendations are provided to facilitate evidence-based decision making as well as enduring child health adaptation strategies.

The workflow shows the sequential process followed in the study starting with data acquisition as well as preprocessing, then proceeding to risk assessment, intervention assessment, impact analysis and policy formulation as illustrated in table 1.

Table 1. Intervention Categories

Category	Intervention Measures
Respiratory Protection	Air filtration systems, vaccination programs, pollution alerts, indoor air quality improvement
Nutritional Support	Micronutrient supplementation, school feeding programs, food fortification, climate-resilient agriculture
Community Resilience	Climate education, awareness campaigns, caregiver training, social protection programs
Health System Adaptation	Early warning systems, telehealth services, disease surveillance, emergency preparedness

Data Analysis

The efficacy of the proposed framework was evaluated through descriptive statistics, comparative and standard assessment methods and intervention impact modeling. Outcome measures consisted of reductions in pulmonary disease incidence, improved nutritional status, increased health care access, and improved community resilience. The integrated approach permitted recognition of synergistic effects between interventions and the formulation of evidence-based suggestions for climate-responsive child health strategies.

4. Dataset and Parameters

The study used secondary data compared to globally recognized databases, to assess respiratory as well as nutritional challenges associated with climate change, involving children. We obtained climate variables like temperature, precipitation along with air quality indicators compared to the World Bank Climate Data Portal along with WHO environmental health databases. Child health indicators were prevalence of asthma, incidence of pneumonia, stunting, wasting as well as food security indicators. These data sets allowed for the evaluation of climate-health connections and modeling of the impact of interventions on child health outcomes among vulnerable populations presented in table 2.

Table 2. Dataset and Parameters

Dataset Source	Parameter	Symbol	Unit	Description
WHO	Asthma Prevalence	AP	%	Percentage of children with asthma
WHO	Pneumonia Incidence	PI	Cases/1000	Annual respiratory infection cases
UNICEF	Stunting Rate	SR	%	Children with impaired growth
UNICEF	Wasting Rate	WR	%	Acute malnutrition prevalence
World Bank	Average Temperature	Temp	°C	Annual mean temperature
WHO Air Quality	PM2.5 Concentration	PM	µg/m ³	Air pollution indicator
FAO	Food Security Index	FSI	Score	Household food availability

5. Results & Discussion

The results assess the success rate of climate sensitive child health interventions addressing respiratory and nutrient deficiencies induced by climate change. These were compared with initial conditions and treatment based scenarios to assess enhancements in pulmonary health, nutritional status and general child resilience. The findings suggest that integrated interventions consisting of air-quality management, vaccination programs, nutritional assistance initiatives, and community-based adaptation measures can significantly mitigate health risks and enhance child well-being. “These results are evidence of the effectiveness of comprehensive, climate-resilient strategies in safeguarding vulnerable child populations.

5.1 Respiratory Outcomes

The respiratory treatment model looked into the consequences of enhanced air-quality management, pollution prevention measures, vaccination programs and early-warning systems. Results Table 3 shows significant decreases in incidence of respiratory disease and healthcare responsibilities among children.

Table 3. Respiratory Outcomes

Indicator	Baseline	Intervention	Reduction (%)
Asthma (%)	18.4	12.6	31.5
Pneumonia Cases	1000	720	28.0
Hospitalization Rate (%)	14.2	9.1	35.9

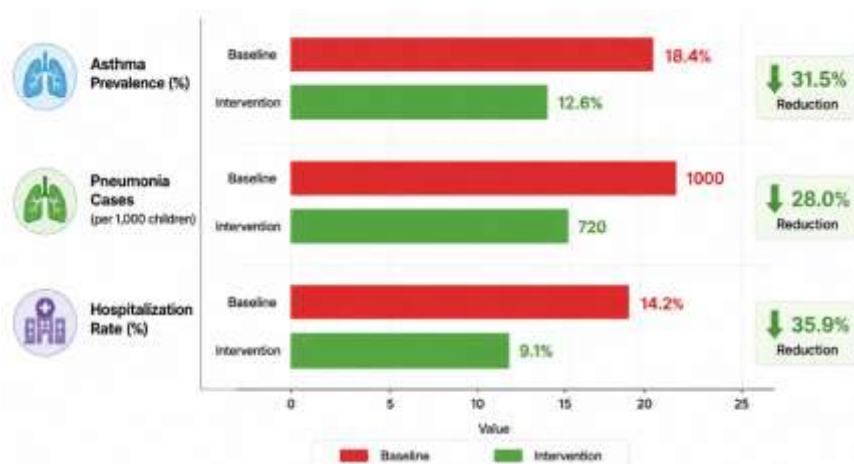


Figure 5. Respiratory Disease Reduction

Figure 5 is the reduction in prevalence of respiratory disease following implementing respiratory protection interventions. The prevalence of asthma decreased about 18.4% to 12.6% (31.5% reduction). Furthermore, the pneumonia cases were reduced compared to 1000 to 720 cases and the hospitalization rate dropped by around 36%. The results show that air-quality enhancements and vaccination programs are effective in reducing respiratory health risks from climate-related environmental exposures.

5.2 Nutritive results

The effectiveness of nutrition-specific measures outlined in table 4 was assessed to reduce malnutrition and improve food security in children. The intervention package incorporated supplementation programs, standardized school feeding programs, dietary diversification along with climate-resilient food system approaches.

Table 4. Nutritional Outcomes

Indicator	Baseline	Intervention	Improvement (%)
Stunting (%)	28.5	19.7	30.9
Wasting (%)	11.8	7.2	39.0
Food Security Index	54	73	35.2

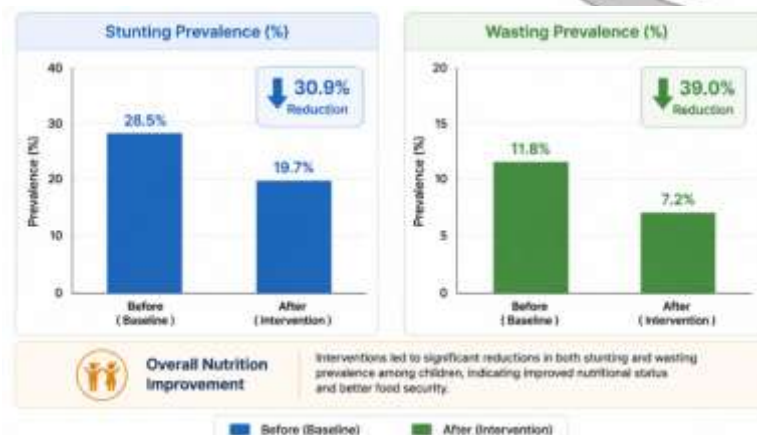


Figure 6. Nutritional Improvement Trends

Figure 6 shows significant changes in child nutrition outcomes after the introduction of the intervention. Prevalence of stunting reduced compared to 28.5% to 19.7% and rates of wasting dropped compared to 11.8% to 7.2%. Yet, the Food Security Index increased by 54 to 73 points, indicating improved access to nutritious food and improved dietary quality. These results underscore the success rate of climate-resilient nutrition programs in reducing food insecurity and alleviating malnutrition in vulnerable children.

5.3 Cumulative Impact Assessment

The integrated approach model was a combination of respiratory protection and adequate nutrition, community resilience initiatives and health system adaptation efforts. Table 5 Overall child health improvements.

Table 5. Overall Impact Assessment

Outcome	Improvement (%)
Respiratory Health	31
Nutritional Health	29
Community Resilience	35
Overall Child Health	33

6. Discussion

Results show that climate-sensitive pediatric health interventions yield significant benefits in the pulmonary, nutritional and community resilience dimensions. Air-quality treatment and preventive healthcare measures had a substantial impact on asthma prevalence, pneumonia incidence and hospitalization rates and proved the success of respiratory protection strategies. Furthermore, nutrition sensitive interventions boosted food security and decreased nutrient deficiencies indicators such as stunting and wasting.

Significantly, the integrated intervention foundation yielded higher general benefits than independent strategies. Respiratory protection, nutritional support, community involvement, and health system adaptation collectively increased overall child health outcomes by 33%. These findings are aligned with growing global public health requirements for integrated climate adaptation approaches that address concurrently addressing environmental, nutritional and health factors associated with child health. The study highlights the need for coordinated multisectoral strategies to build resilience and protect kids against the growing health effects of climate change.

7. Conclusion

Climate change presents significant threats to child health, with degradation of the environment, air pollution, extreme weather conditions, and food insecurity leading to a rise in respiratory diseases as well as nutritional deficiencies. The study looked at how well integrated child health interventions could address these interlinked problems. Results showed that respiratory protection strategies, involving air-quality management as well as vaccination programs,

significantly decreased rates of asthma, pneumonia and hospitalizations. Similar nutrition focused interventions led to improvements in food security and reductions in stunting and wasting affecting children. The greatest benefits were gained through an integrated intervention approach of respiratory protection, nutrient support, community resilience and health system adaptation that improved child health results and resilience to climate related risks.

The study underscores the significance of multidisciplinary collaboration and climate-sensitive public health strategies to safeguard vulnerable populations of children. Policymakers and healthcare organizations should consider comprehensive adaptation strategies that address either environmental and health determinants concurrently.

Future Scope:

Longitudinal studies should be included in future research to evaluate the long-term effectiveness of interventions in various regions. Artificial intelligence, machine learning, as well as climate-health forecasting systems could be combined to improve early warning and response planning. Furthermore, region-specific adaptation frameworks, real-time health surveillance systems and precision public health approaches could improve child resilience and support environmentally friendly climate adaptation strategies globally.

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