

Review

Content Focus and Effectiveness of Climate Change and Human Health Education in Schools: A Scoping Review

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Abstract: The creation of standardized, impactful, evidence-based curricula and resources addressing climate change and health issues in schools is seen as vital in combating the impending risks of climate change on human health. A scoping review of the literature was conducted to identify peer-reviewed studies related to climate change and health education in schools and to examine their content focus and evaluation. The search covered five electronic databases and considered English peer-reviewed publications from 2000 to May 2022. Nine studies met the inclusion criteria, representing various countries and employing different study designs. Climate change and health adaptation content dominated the included studies with varying foci, including heatwaves, disaster preparation, flood education, vector-borne diseases, and general climate change and health adaptation. Other studies utilized climate change and health topics to develop skills, employ the use of information and communication technologies within curricula, and highlight the interconnectedness between the environment and health. Although heterogeneous in their methodology, the intervention studies and evaluations included (five out of nine) found that interventions impacted knowledge, awareness or perception. Two studies also highlighted the intergenerational learning potential of the interventions. While there is a growing body of research in the field, more research is necessary to measure their effectiveness and thereby develop suitable educational strategies.

Keywords: health; climate change education; schools; primary education; secondary education; scoping review



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1. Introduction

Since the onset of the industrial revolution, the concentrations of greenhouse gases have been on the rise, primarily due to human activities like the burning of fossil fuels, animal farming, deforestation, irrigated agriculture, and the production of cement [1]. This phenomenon has resulted in anthropogenic climate change, which manifests in rising temperatures, changes in the hydrological cycle, the rising of sea levels, and more persistent occurrences of extreme weather such as heat waves [2]. Consequently, these climate and weather changes affect the occurrence and spread of diseases that are sensitive to climate, such as food- and waterborne diseases, and aggravate health conditions associated with air pollution and airborne allergens [3,4].

The rise in temperature and decline in air quality caused by climate change have become a significant public health issue, leading to an increasing number of illnesses and deaths [1,5]. According to the World Health Organization (WHO), about 23% of global deaths and 26% of deaths among children under five years old are attributed to modifiable environmental factors [6]. Climate change is exacerbating the health risks associated with climate-sensitive factors and outcomes worldwide, with children being particularly vulnerable due to their increased exposure to climate-related hazards, higher sensitivity, dependence on caretakers [7,8], and incomplete physical, physiological, and cognitive maturation [9,10].

1.1. Importance of Climate Change Education

Recognizing the urgency of addressing climate change on a global scale, the UNFCCC has emphasized the importance of education in confronting this challenge [11,12]. Education for sustainable development (ESD) is a broader concept that encompasses the economic, social, and cultural aspects of sustainability. It aims to empower learners to take action for a sustainable future and to develop critical-thinking and problem-solving skills [13]. The “Curriculum Framework ESD” includes 21 thematic areas in order to achieve sustainable development, where global environmental change is one of them [13,14]. In this context, climate change education is an extension of the ESD, focusing specifically on increasing public understanding of climate change and its impacts, as well as promoting behavioral changes to mitigate and adapt to its effects. The UNFCCC has laid the groundwork for climate change education as it is currently understood [15].

Climate change education integrates the scientific fundamentals of climate change with a wider perspective on the interconnection between climate and various aspects of human societies [16]. The aim is to equip learners with both mitigation and adaptation skills [17,18], enabling them to make informed decisions, change attitudes and behaviors [19,20], and acquire essential competencies to mitigate and adapt to climate change [10,16]. The ultimate goal is to equip individuals with “climate literacy” [16,21] and empower them to address the challenge of climate change.

1.2. The Need for Education on Climate Change and Human Health in Schools

In light of the negative impacts of climate change on health, efforts are being made to shift the focus from only “climate literacy” to “climate and health literacy,” representing one specific focus among many. Recent studies emphasize the importance of proactive efforts by healthcare providers, governments, corporations, and society at large to actively tackle the issue of climate change and its consequences on the wellbeing and health of the population [22–25]. However, the current educational framework falls short in adequately preparing students, as it is restricted to healthcare professionals and has a reduced scope and content perspective [25]. A comprehensive educational agenda at all levels, encompassing a wide range of subjects and disciplines, is seen as a vital element of the worldwide response to climate change [24–26]. To this end, schools are commonly recognized as the primary setting for promoting education on climate change and its impact on public health [27–29]. Limaye et al. (2020) consider an individual to be climate and health literate when they are able to acknowledge the correlation between climate change and health, effectively convey the risks, evaluate data, understand uncertainties, and make well-informed and responsible decisions that safeguard personal wellbeing. Additionally, such individuals are capable of advocating for broader policies that aim to protect public health. Proficiency in climate and health literacy is anticipated to be developed gradually, with younger students attaining functional levels of competency during their primary and secondary education [25].

To minimize the impacts of climate change on health, focusing on both mitigation and adaptation strategies is essential [30]. Mitigation efforts aim to reduce emissions, while adaptation measures prepare for the no-longer-avoidable impacts [2,24]. Therefore, addressing climate change is crucial for improving global health [5,22].

Conceptually, the existing public health levels of prevention can be applied to categorize the effects on climate change on health. Wheeler and Watts (2018) suggested that the primary, secondary, and tertiary prevention categories are helpful in being applied as guidelines for climate change adaptation incorporation into public health. In that regard, reducing human exposure to climate change impacts could be considered a form of primary prevention, such as urban greening to reduce urban heat island prevalence and the associated risks of intense heatwaves [31,32]. Secondary prevention is concerned with preventing negative health outcomes due to exposure that is unavoidable, such as enhanced surveillance programs for vector-borne diseases. Finally, the long-term, more systemic

health effects of climate change are reduced by tertiary prevention, such as measures or treatments to ease the physical and social impacts of diseases and their symptoms [31].

Health co-benefits occur when mitigation strategies generate health advantages outside their scope of reducing greenhouse gas emissions [33]. Examples include riding a bike instead of driving a car, which not only reduces the emission of gases but also benefits the health of the individual making this choice [34]. Other co-benefits of mitigation strategies include dietary choices, such as avoiding meat [35] or reducing dairy consumption [36], etc.

There is currently a lack of evidence and research on the scope, content, and effectiveness of climate change education [37], although there is growing interest in this area [3,28]. According to a report, many climate change programs primarily concentrate on understanding the causes of climate change, while there are fewer initiatives that address issues related to mitigation or adaptation [28]. It is worth noting that this report did not consider the health implications of climate change education.

1.3. Objective and Review Questions

This review aims to fill the research gap regarding the relationship between climate change education and health, focusing specifically on educational settings within schools, as they have a significant impact on attitudes and behavior [30,38]. This review aims to investigate the content focus of climate change and health education, namely to assess if the focus lies on climate mitigation and health or climate adaptation and health. This review addresses the following research questions:

- What is the content of climate change topics focusing on human health in schools?
- Is the effectiveness of school-based climate change and health programs evaluated?

2. Materials and Methods

The JBI (The Joanna Briggs Institute) approach guided the development of the protocol and this review. The JBI approach was followed due to it being the most thorough and up-to-date approach for conducting scoping reviews [39]. The protocol of this scoping review adhered to the PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation [40].

A scoping review was deemed the most suitable approach to meet the research objectives, as it offers a comprehensive assessment of the quantity and distribution of existing evidence [40]. The protocol of this review was published [41]. Information regarding the PCC framework, databases, keywords, and medical headings used are given in the published protocol.

2.1. Review Question(s)

The PCC framework, as recommended by the JBI, guided the formulation of the research questions, as well as item 4 in the PRISMA checklist [40,42]. The study aims and review questions were conceptualized using the PCC framework, namely identifying the key concepts or elements: population or participants, concept, and context.

2.2. Identifying Relevant Studies

In May 2022, five databases were explored with pre-determined search strings. These databases were PubMed, Web of Science (Core Collection), EMBASE, GreenFILE, and ERIC (Education Resource Information Centre).

To create the search strings and find suitable keywords and MeSH phrases, PubMed searches were first performed. Following that, appropriate search terms were created for the other explored databases. MeSH and keywords such as “climate change”, “education”, “schools”, and “health” were used to create fitting search strings.

2.3. Study Selection

All records from the databases were imported into EndNote, where they were combined together, and duplicates were removed. The screening process consisted of pilot

screening, title and abstract screening, and full-text screening. LR and SK reviewed the studies independently based on the inclusion and exclusion criteria.

The studies were included if they were: (1) peer reviewed, (2) published from 2000 and onwards without any geographical restriction, (3) published in English, and (4) focused on the linkage between climate change and health. During the full-text review, any studies not matching the inclusion criteria were removed, and a record of the excluded studies was kept. Differences in opinion were resolved through discussion between the reviewers, and in case of disagreement, a third reviewer was involved (MB).

Research exploring the intersection of climate change and health gained momentum following the adoption of the Millennium Development Goals in 2000 [43].

Exclusion Criteria

To overcome methodological challenges, the review did not include grey literature available in the public domain, such as curricula, journals, reports, and process documentation obtained from websites. Methodological challenges included searchability and indexing, quality control, heterogeneity, etc., which resulted in reduced reproducibility. Additionally, one of the aims of this review lay in identifying peer-reviewed papers evaluating climate change and health programs within school settings.

Studies that did not explicitly address climate change and health linkages were excluded. For instance, papers addressing climate-sensitive diseases but in the context of environmental health that did not include climate change in the theoretical framework and/or learning outcomes were excluded.

2.4. Data Extraction

Reviewer one, LR, performed data extraction in Microsoft Excel. LR drafted the first version of the data extraction sheet. In agreement with reviewer two, SK, adjustments were made if necessary, and the extraction sheet was finalized. LR performed the data extraction. SK and reviewer three, MB, counterchecked the work and provided their feedback.

2.5. Summarizing and Reporting the Results

Tables were created with the following extracted data: authors' name, publication year, publication type, geographical location, school level of learners or age of learners, health topics, and content focus (Tables 1 and 2). Findings were summarized narratively using a thematic analysis approach [44]. Quality appraisal was not performed in this review. Arksey and O'Malley [45] and Pollock et al. [46] note that scoping reviews do not primarily focus on conducting quality appraisals of the evidence.

Table 1. Characteristics of the included studies.

Reference	Country	Type of Study	Age/School Level	Aim of the Article
Gkatzos, 2017 [47]	Greece	Case study	Grade 5 and 6	This article presents an effort to integrate the issues of climate change and children's rights into the Greek primary school curriculum through the use of information and communication technologies (ICTs).
Kabir et al., 2015 [48]	Bangladesh	Intervention Evaluation	Secondary school students (grade 6–10)	To test the effectiveness of a developed manual for increasing the knowledge level of school children about climate change and health adaptation.
Keselman et al., 2012 [49]	US	Descriptive	High school students	A description of two projects aimed at helping students to develop information-seeking and evaluation and argumentation skills and applying them to complex socio-scientific issues that have a bearing on students' daily lives. The first effort involved co-designing an afterschool environmental health club curriculum with an interdisciplinary team of middle-school teachers. The second effort was the development and implementation of a week-long school drinking water quality debate activity in a high school environmental science classroom.
Li et al., 2022 [50]	China	Intervention Evaluation	Primary school students	An evaluation of the effectiveness of a primary-school-based intervention program against heatwave and climate change in China to provide evidence for the development of policies for adaptation to climate change.
Parejo et al., 2021 [51]	Ghana	Case study	Children	A qualitative investigation in the form of a case study, with data derived from an educational project focused on plastics as a vehicle for environmental education.
Tomokawa et al., 2021 [52]	Lao	Case study	School-aged children	To review the transitions in health education, environmental education and education for sustainable development (ESD) in various developing countries. Moreover, a discussion was conducted relating to these disciplines and the possible roles that ecohealth education can play.
Williams et al., 2017 [53]	UK	Intervention Evaluation	Age 7–9	Using an action-based, participatory methodology, a creative and inclusive flood education resource was developed as a stimulus for learning and was evaluated.
Zhong et al., 2021 [54]	China	Intervention Evaluation	Age 8–10	This study investigated a three-year disaster education program conducted in schools.
Bedoya-Rodriguez et al., 2022 [55]	Columbia	KAP survey	Grade 6–11	This study aimed (a) to determine the abundance of species of mosquitoes with the potential capacity to transmit infectious diseases in a school located in the Cauca district and (b) to teach students self-care and care for the environment to protect themselves from vector-borne diseases.

Table 2. Content focus and description of content.

Reference	Content Focus	Climate Change and Health Adaptation/Mitigation or Levels of Prevention	Description of Content
Gkatzos (2017) [47]	Climate change education and human rights	Mitigation	“The Health and Climate Change curriculum area consists of three units: (1) Health as a Basic Need, (2) Health as a Right, (3) Right to Health and Climate Change. Case studies with actions to mitigate climate change and the denial of the right to health caused by the its impacts. “Additionally, learners are asked to find ways of action in order to intervene in this relation. “
Kabir et al. (2015) [48]	Climate change and health adaptation	Climate change and health adaptation	“The manual contains seven chapters that include essential knowledge about climate change and health issues, the ‘do’s and don’ts’ during extreme weather events, and adaptation activities “. The manual has seven chapters: chapter one deals with issues of climate and how the climate is changing. Climate change and its effect on health, climate sensitive diseases and other environmental health issues are discussed in chapter two. In chapter three, the risk management of health hazards due to Climate Change is addressed. Conservation of the environment and natural resources of Bangladesh is the content of chapter four. Chapter five comprises three case studies that illustrate climate change and health protection issues. Chapter six describes how to reduce environmental pollution (air, soil, water, river, sound) and how to keep a healthy life style. Chapter seven outline the plan for three days of practical lessons on climate change and health adaptation.”
Keselman et al. (2012) [49]	Water pollution and climate change/environmental health and development of argumentation skills	Conceptual understanding of climate change/environmental health and water pollution	“... how climate change may produce direct and indirect health effects (e.g., rising winter temperatures leading to longer survival of infection-carrying insects)”
Li et al. (2022) [50]	Heatwave education	Climate change and health adaptation	“The main health education activities included running related health education courses, launching lectures and class meetings on climate change adaptation and children’s health protection, and holding competitions involving blackboard newspapers, drawing, and writing. The school clinic was required to prepare enough medicine to prevent and treat heatstroke in summer.”
Parejo et al. (2021) [51]	Plastic pollution	Mitigation	Impacts of plastic burning and pollution on health
Tomokawa et al. (2021) [52]	Ecohealth	Conceptual understanding of climate change and health (country-specific)	“Chapter 2: Ecosystem and human health -Ecosystem and water-related diseases and food-borne diseases -Endemic diseases and ecosystem -Water and human health -Soil pollution, forest and human health -Waste management and human health -Climate change and human health”

Table 2. *Cont.*

Reference	Content Focus	Climate Change and Health Adaptation/Mitigation or Levels of Prevention	Description of Content
Williams et al. (2017) [53]	Flood education	Climate change and health adaptation	Young children learned about flooding and preparedness and that intergenerational learning from child to parent can also occur, with children transferring the messages learned in school to home.
Zhong et al. (2021) [54]	Disaster education/flood education	Climate change and health adaptation	“The disaster awareness sub-part asked specific questions about flood injury prevention and the risks of post-flood secondary disasters of gastrointestinal and respiratory diseases. The health-related behaviors sub-part sought information about coping with disasters, including questions about drinking water safety and hands washing habits to prevent infectious diseases.”
Bedoya-Rodriguez et al. (2022) [55]	Mosquitos (Diptera: Culicidae) and environmental education	Adaptation/prevention and management of VBDs	The educational booklet contained information on VBD: booklet presentation, context, sites of mosquito presence, mosquito biology, mosquito-borne diseases, Culicidae mosquito species, characteristics of dengue, malaria, zika, chikungunya, educational activities, and bibliography.

3. Results

Searching the five databases resulted in nine hundred and seventy-three papers. Out of these, duplicates were removed. The titles and the abstracts of the remaining records were screened against the inclusion and exclusion criteria, where 72 were deemed as relevant. Out of these, six records were not accessible or available, resulting in sixty-six papers which were screened full-text. Finally, nine of these records fit the criteria for our evaluation and were included. The process of choosing and identifying articles is depicted in the PRISMA flow diagram of the research shown below (Figure 1).

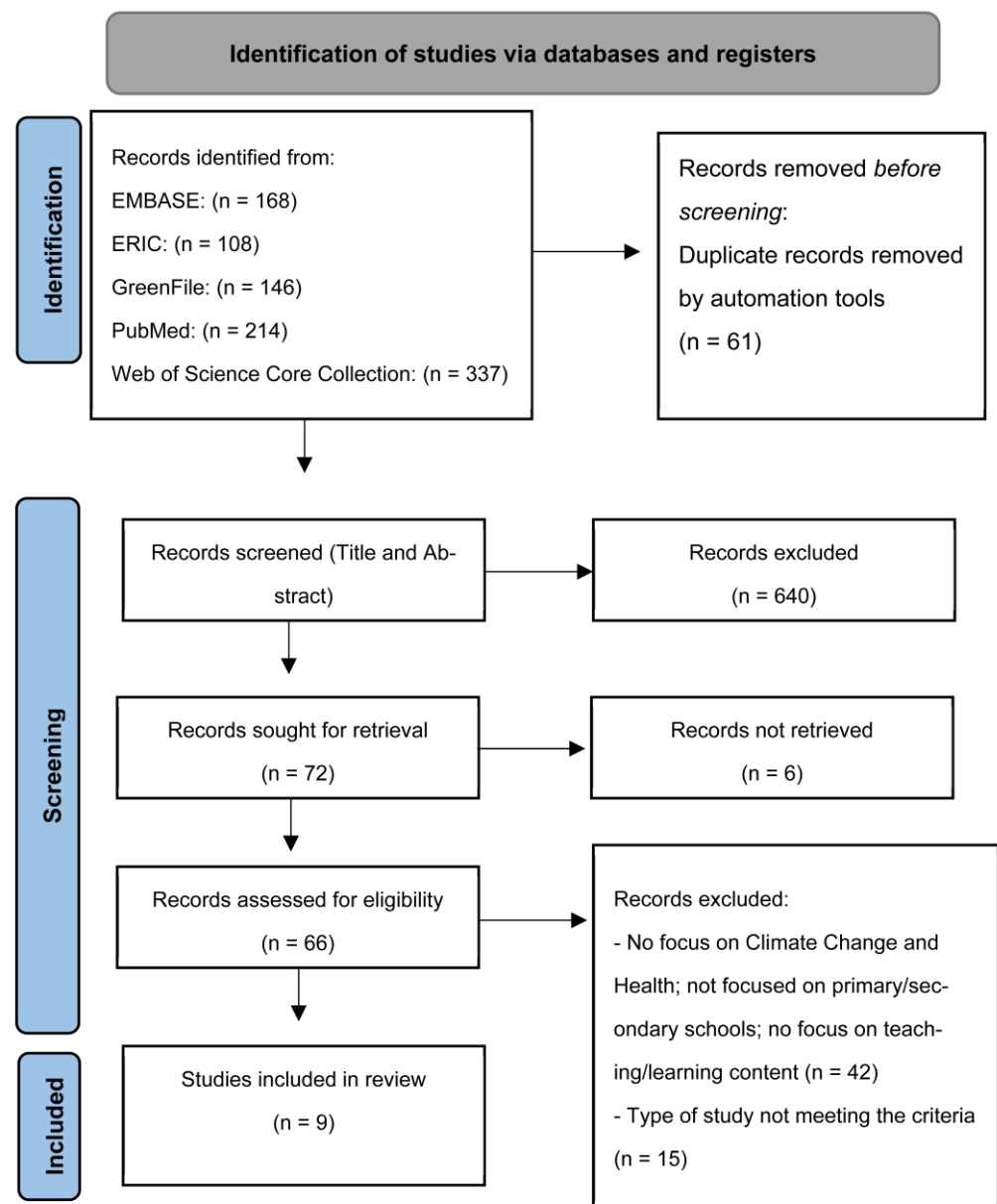


Figure 1. PRISMA flowchart.

3.1. Description of Studies

The review's nine articles were published between 2012 and 2022, with the most recent being published in 2022 [50,55], three published in 2021 [51,52,54], and two published in 2017 [47,53]. Kabir et al. was published in 2015 [48] and Keselman et al. in 2012 [49]. The research was conducted in various countries and represented diverse geographical areas. Two papers were published in China [50,54], and the rest were all published in

different countries, namely Greece [47], Bangladesh [48], US [49], Ghana [51], Lao [52], United Kingdom [53], and Colombia [55]. All studies focused on primary and secondary school; however, varying school grades or age groups were studied, ranging from grade 1 to grade 11 and including ages up to 15.

Three studies focused on grades 5 to 11, namely grade 5–6 [47], grade 6–10 [48], and 6–11 [55], with the two latter being secondary school students. However, the rest of the papers did not mention the grade level, rather they mentioned the age, where they ranged from 7–10 years old. Williams et al. (2017) [53] focused on 7–9 years, and Zhong et al. (2021) [54] focused on a broader age group, i.e., 8–10 years. These age groups mainly fell between the grade levels of 2 and 5. The rest of the studies [49–52] did not specify the exact age or school level of the participants, but they were described as school-aged children or young learners. The overall characteristics of the included studies are presented in Table 1.

3.2. Methodology and Objective of the Studies

The studies included a variety of study designs, including qualitative studies, surveys, and intervention studies. Most of the studies included were intervention evaluations [48,50,53,54]. Three were case studies [47,51,52], one was a knowledge, attitude, and practice (KAP) survey [55], and one was a description of a curriculum implementation [49].

The papers that conducted intervention evaluations evaluated education programs with various content foci. Kabir et al. (2015) [48] tested the effectiveness of a manual in increasing the knowledge level of school children about climate change and health adaptation implemented in Bangladesh. Similarly, Li et al. (2022) [50] aimed to evaluate the effectiveness of a primary-school-based intervention program on climate change adaptation, specifically focusing on heatwaves in China. Zhong et al. (2021) [54] also evaluates a three-year disaster education program carried out in schools in China. Finally, Williams et al. (2017) [53] developed and evaluated a flood education resource used to facilitate learning.

Two studies described interventions or projects that were implemented in order to increase knowledge regarding climate change and environmental health issues. Gkatzos (2017) [47] described attempts to include the issues of climate change and children's rights into the Greek primary school curriculum via the utilization of information and communication technologies (ICTs). On the other hand, Keselman et al. (2012) [49] described two collaborative efforts that attempted to assist students in cultivating skills related to information seeking, evaluation, argumentation, and their practical application in complex socio-scientific issues relevant to their daily lives. This entailed collaborating with a team of middle-school teachers to co-design an afterschool environmental health club curriculum. The second initiatives included the development and execution of a week-long debate activity focusing on school drinking water quality in a high school environmental science classroom.

Parejo et al. (2021) [51] introduced a qualitative investigation in the form of a case study, with data retrieved from an educational project centred around plastics as a vehicle for environmental education. Tomokawa et al. (2021) [52] reviewed the transitions in health education, environmental education, and education for sustainable development (ESD) in different developing countries, with a particular focus on the potential role of ecohealth education in integrating these fields.

Finally, Bedoya-Rodriguez et al. (2022) [55] assessed the presence and abundance of mosquito species capable of transmitting infectious diseases within a school situated in the Cauca district. Additionally, the study aimed to educate students about self-care practices and environmental stewardship to safeguard themselves from vector-borne diseases.

3.3. Content Focus and Description

Due to the diverse nature of the studies, not all of them provided the same level of detail regarding the program or content focus. However, the studies included had

heterogenous content foci, with the majority of them focusing on climate change and health adaptation. The foci included the prevention and management of VBDs, heatwaves, flood education and disaster education, and general climate change and health adaptation.

Gkatzos (2017) [47] focused on climate change and children's rights and using information communication technologies as a vessel to increase the knowledge. The program developed for this purpose included a curriculum area focused on "Climate Change and Health Protection". This curriculum consisted of three units: "(1) Health as a Basic Need, (2) Health as a Right, (3) Right to Health and Climate Change" (p. 12). Under the framework of the proposed curriculum, "Climate Change and Human Rights" included units with health in focus. The units were complemented by case studies illustrating different actions for climate change mitigation as well as the denial of the right to health caused by climate change impacts. Therefore, it can be inferred that the focus of this program was mitigation.

Kabir et al. [48] gave a detailed description of a manual developed with the aim of developing the knowledge regarding climate change and health adaptation. The manual developed consisted of seven chapters: Chapter one focused on the topic of climate, including the changes occurring in the climate. Chapter two delved into the discussion of climate change and its impact on health, along with an exploration of climate-sensitive diseases and other environmental health concerns. In chapter three, the focus shifted to the management of health hazards associated with climate change. The content of chapter four centered around the conservation of Bangladesh's environment and natural resources. Chapter five comprised three case studies that provided examples illustrating the interplay between climate change and health protection issues. Chapter six addressed strategies for reducing environmental pollution (air, soil, water, river, and sound) and promoting a healthy lifestyle. Finally, chapter seven outlined a plan for practical lessons spanning three days, specifically targeting climate change and health adaptation.

Keselman et al. (2012) [49] aimed to foster the development of skills related to information seeking, evaluation, and argumentation, and their practical application in intricate socio-scientific matters. Content wise, they focused on providing a conceptual understanding of environmental health, with an emphasis on water pollution and climate change and their link to health.

Li et al. (2022) [50] focused on heatwaves and climate change in a school-based intervention.

At the intervention school, health education initiatives were implemented to enhance students' awareness and preparedness in dealing with extreme heat. These activities encompassed health education courses, lectures, and class meetings that focused on climate change adaptation and safeguarding children's health. Additionally, competitions involving blackboard newspapers, drawings, and writings were organized as part of the health education efforts.

Additionally, the intervention included extra activities that were used to include parents through intergenerational learning. For instance, the students were asked to take part in practice exercises against climate change or heatwaves over the school summer break, such as observing and documenting how their family or friends coped with the heatwaves. The intervention school's students were also asked to inform their families about the effects of climate change and how they will affect their health. Furthermore, the intervention consisted of ramping up the commitment of the schools to combat heatwaves, such as by stocking up on enough medication to treat and prevent heatstroke in the summer.

Parejo et al. (2021) [51] focused on increasing students' knowledge regarding plastic pollution via using plastics as a vehicle for reaching environmental education learning goals, such as by making materials for learning and play from recycled plastic waste, etc. In terms of health, the study stated that the intervention attempted to enlighten the students on the impacts of plastic burning and pollution on health. Therefore, the focus of this intervention was rather a conceptual understanding of plastic pollution and climate change mitigation. They mentioned in the theoretical framework the linkage of plastic pollution and human health; however, it was not specified if this linkage was a learning goal within the program.

Tomokawa (2021) [52], on the other hand, proposed the inclusion of the ecohealth concept in the curricula of schools in Laos, within which climate change and health topics were also offered without providing a specific content focus. Additionally, the ecohealth curricula included other topics which overlapped with climate change and health. For instance, chapter 2 focused on the ecosystem and human health, where the subtopics included: the ecosystem, water-related diseases, and food-borne diseases; endemic diseases and the ecosystem; human health and water; forests, soil pollution, and human health; human health and waste management; and climate change and human health.

Williams et al. (2017) [53] focused on flood education. Zhong et al. (2021) [54] reported on a school-based disaster education program, whereas Bedoya-Rodriguez et al. (2022) [55] focused on vector-borne diseases. The latter study identified climate change as being another factor or issue that exacerbates the diseases addressed in the learning outcomes. However, it is unknown to what extent the linkage of climate change and health was included in the teaching content or learning outcomes.

An overview of the content focus and a description is given in Table 2.

3.4. Effectiveness of Programs

According to Kabir et al. (2015) [48], school-based interventions for climate change and health adaptation were successful in raising schoolchildren's understanding of the subject. A cluster-randomized intervention experiment was carried out with 60 schools in Bangladesh, involving 3293 secondary school students. In total, 1778 children from the 30 control schools received a leaflet on climate change and health risks, whereas a total of 1515 students from the 30 intervention schools instead received the intervention through classroom instruction based on the school manual. At both the intervention and control schools, a post-intervention exam using the same pre-test questionnaire was conducted six months later. After a multi-level linear regression model took into account the pre-test score and other covariates, the intervention group's post-test score was 17.42% (95% CI: 14.45 to 20.38, $p = 0.001$) higher than the control group's score.

Li et al. (2022) [50] found that their education program in primary school focusing on heat and health was an effective approach to improve the awareness and behavior of students as well as their parents to better adapt to climate change and heatwaves. Two primary schools in China were randomly selected as intervention and control schools. Before and after the intervention, a questionnaire survey was administered to a total of 427 and 405 primary school students in grades three to five at the intervention school. In parallel, a baseline and endline questionnaire survey was conducted with 499 and 539 primary school students in the same grade range at the control school. The objective of the health education implemented at the intervention school was to enhance students' awareness and ability to handle extreme heat. The survey assessed the knowledge, attitude, and practice (KAP) of both students and their parents at both schools, before and after the intervention, through the use of questionnaires.

The changes in the knowledge, attitude, and practice (KAP) scores following the intervention were assessed using multivariable difference-in-difference (DID) analysis, with adjustments being made for factors such as age and gender. The findings revealed that the knowledge scores of both students and their parents increased by 19.9% (95%CI: 16.3%, 23.6%) and 22.5% (95%CI: 17.8%, 27.1%), respectively. Similarly, the attitude scores increased by 9.60% (95%CI: 5.35%, 13.9%) among the students and 7.22% (95%CI: 0.96%, 13.5%) among the parents. The practice scores were also improved, with an increase of 9.94% (95%CI: 8.26%, 18.3%) for the students and 5.22% (95%CI: 0.73%, 9.71%) for the parents. The changes in the KAP scores were slightly higher for boys compared to girls, and older students exhibited greater score changes compared to younger students. Among the parents, those with higher education levels experienced more significant score changes, and females showed greater improvements in scores compared to males.

Williams et al. (2017) [53] revealed that young children can learn about flooding and preparedness as well as allow for intergenerational learning. Utilizing an action-

based, participatory methodology with seven- to nine-year-old children, a flood education resource was developed as a facilitator and motivator for learning. The study involved sixty-eight children from two schools located in deprived areas. Data collection occurred in three phases: Phase 1 involved co-curricular activities in small groups at school where children created “treasure boxes” containing information about flood preparedness. Phase 2 involved individual interviews with children followed by a researcher debriefing and the sharing of headline results with the class. Phase 3 involved telephone interviews with 21 parents to explore intergenerational learning and behavior change. A qualitative analysis of the transcribed data using the NVivo software was conducted to identify patterns and themes. Ethical clearance and informed consent were obtained, and validation of themes was achieved through inter-rater reliability testing. The intervention evaluation showed that the young children were able to learn about flooding and better prepare themselves in cases of flooding. Additionally, it was found that intergenerational learning was possible where children transferred the knowledge and messages retrieved at school to home. However, it should be noted that key factors such as relationships between the parents and children and the parent’s risk perception influenced the intergenerational learning outcomes.

Zhong (2021) [54] used a quasi-experimental design, comparing a group of children who received disaster education with a control group who did not in 45 primary schools. The survey included questions about the children’s flood risk perceptions, knowledge of flood prevention and response, and attitudes towards disaster preparedness. In three pilot counties, stratified cluster sampling was used to separately investigate the risk perceptions of 2105 children (baseline) and 1710 children (post-intervention), respectively, aged 8–12, in 45 primary schools. The effectiveness of the various interventions, including classroom education, propaganda posters, professional guidance, social education (television, radio, friends, and internet), and risk-related parent–child interactions, was evaluated using ordinary least-squares regression and the propensity score matching method (PSM). Interaction items and a structure equation model (SEM) were employed to examine their co-influencing mechanisms. The results indicated that classroom education (coeff. = 0.040; $p < 0.05$), propaganda posters (coeff. = 0.024; $p < 0.05$), and professional guidance (coeff. = 0.016; $p < 0.1$) had significant positive effects on children’s perception of flood risks. An overview of the interventions, outcome measures, and results is given in Table 3.

Table 3. Intervention studies, outcome measures, and results.

Study	Participants	Intervention	Outcome Measures	Results
Kabir et al., 2015 [48]	3293 students	Classroom instruction based on school manual	Post-test scores measuring understanding of climate change and health adaptation	Intervention group had a 17.42% higher post-test score compared to control group (95% CI: 14.45 to 20.38).
Li et al., 2022 [54]	Students (1870), parents (1264)	Health education program in primary school	Knowledge, attitude, and practice (KAP) scores	Knowledge, attitude, and practice scores increased significantly after intervention. The total score for KAP increased by 14.8% (95%CI: 10.8%, 18.3%) after intervention.
Williams et al., 2017 [53]	68 children	Flood education resource	Thematic analysis of transcribed data from interviews with children and parents	Young children can learn about flooding and preparedness; intergenerational learning is possible.
Zhong et al., 2021 [54]	2105 children	Disaster education	Flood risk perceptions	The classroom education (coeff. = 0.040; $p < 0.05$) had significantly positive effects on the flood risk perception of children.
Bedoya Rodriguez et al., 2022 [48]	54 students	Educational booklet and online conference on VBDs	Pretest and a post-test questionnaire (KAP)	There were significant differences detected between the pre-test and post-test means, revealed by the nonparametric Wilcoxon signed-rank test for related samples (pre-test mean = 2.78; post-test mean = 4.31, $p < 0.05$).

4. Discussion

4.1. Conceptual Intersections and Continuum

During the screening and analysis of the studies, it was brought to the attention of the researchers that the concept of environmental education, education for sustainable development, education for sustainability, and climate change education were being used interchangeably. This issue was also raised by different researchers [56–58], who reviewed papers in these fields and proposed establishing distinctions and definitions. For instance, taking into account the confusion around these concepts, Maipas et al. (2021) [56], in their paper and research, treated these concepts as synonymous. The authors further proposed a new concept, which was built on concepts such as EE and ESD but with a focus on health. They proposed environmental health education as a strategic response and strategy against environmental health threats, such as climate change and urban air pollution. This further denotes the diverse concepts available to explain the education with a focus on environment and health, or alternatively the various frameworks under which environmental health or climate change and health issues might be offered.

For instance, during screening, some studies that addressed potential climate-sensitive diseases or other climate-related impacts on health, such as Dengue [59], Aedes [60], and UV exposure [61], were offered as part of environmental health programs. They did not refer to climate change or the linkages to it, nor was it included in the theoretical framework or in the learning outcomes. These studies were excluded from the review on the grounds that they did not focus on the linkages between climate change and health.

This confusion and the lack of a unified concept that incorporated climate and health learning goals was also evident in the papers included. Although most studies addressed the same issue, that is, climate change and health impacts, the framework under which these programs were offered varied. Climate change education is a part of environmental education, which focuses on increasing the public understanding of climate change and its impacts as well as promoting behavioral changes to mitigate and adapt to its effects; however, not all the interventions or curricula topics were offered in support of or under the framework of EE/CEE. There were only two studies whose teaching/learning content was offered in support of environmental education [51,55]. The heatwave intervention was offered in support of health education [50], whereas Keselman (2012) [49] offered learning activities as part of an afterschool environmental health club. There were two studies [53,54] whose interventions supported or was offered as part of disaster education, with the latter focusing on flood education. Kabir et al. (2015) [48] did not specify the framework under which the program was offered; however, it was stated that the program was developed according to a WHO South East Asia Regional Office (2008) manual for school children to enhance a child-centred approach to attain a life-style adaptation for reducing health vulnerability. In addition, their theoretical framework focused on health education offered in schools; hence, it can be assumed that the program was offered as part of health education. However, the program by Gkatzos (2017) [47] was the only program was offered under the framework of CCE.

However, Tomokawa (2021) [52] proposed the approach of ecohealth, under which, among others, climate and health learning goals were given. Ecohealth is an approach that focuses on the relationships between human health and the environment. It seeks to promote a holistic and integrated approach to health that considers environmental, social, economic, and cultural factors. Waltner-Toews describes ecohealth as “sustainable human and animal health and well-being, through healthier ecosystems” [62] (p. 519). Figure 2 depicts the broad intersections of all the concepts present within the included studies. Generally, the intersections of ESD, environmental education, and health education resulted in the emergence of environmental health education, climate change education, ecohealth education, and disaster education. In the included studies, all these concepts addressed aspects of sustainability, health, and the environment, with a particular focus on climate change. They attempted to foster knowledge or skills to understand, mitigate, or adapt to the impacts of climate change on human health, although under different labels.

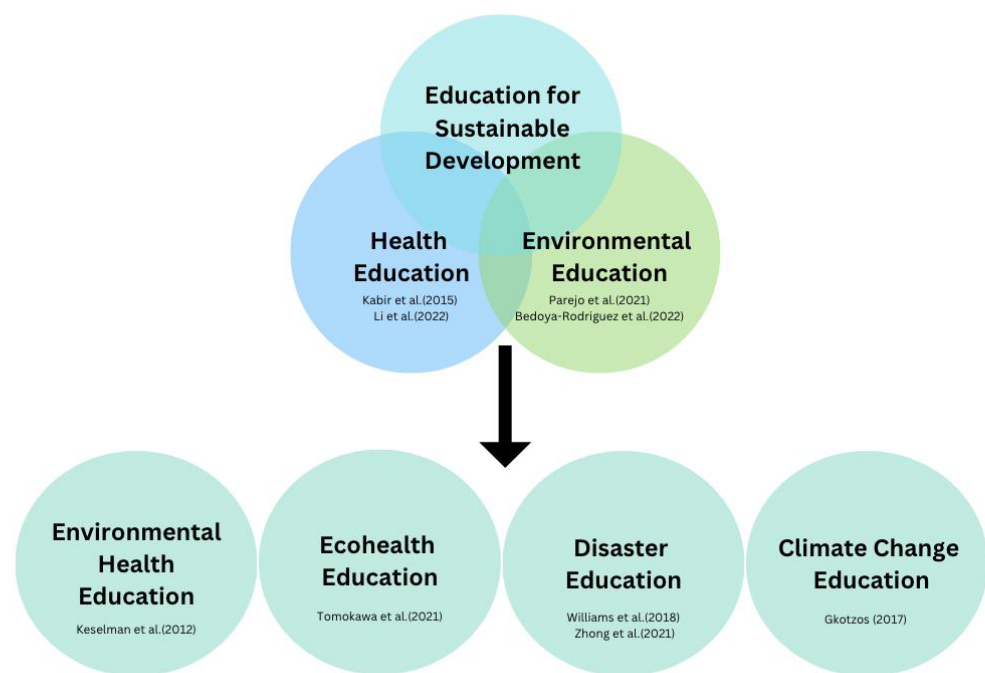


Figure 2. Overview of different frameworks present in the included studies (Kabir et al. (2015) [48]; Li et al. (2022) [50]; Parejo et al. (2021) [51]; Bedoya-Rodriguez et al. (2022) [55]; Keselman et al. (2012) [49]; Tomokawa et al. (2021) [52]; Williams et al. (2018) [53]; Zhong et al. (2021) [54]; Gkatzos (2017) [47]).

Apart from ecohealth, other emerging concepts such as “Planetary Health” propose climate change and health topics to be included in curricula. Von Borries (2020) [63] emphasized the urgent need for planetary health education in primary and secondary schools, especially in the wake of the COVID-19 pandemic being at the concoction of the human–animal–environment nexus. The approach of planetary health is deemed as an effective vessel in raising awareness and inciting climate action among the youth [63] and further deepening the knowledge of the social injustices of climate change [64].

4.2. Climate Change and Health Knowledge, Barriers, and Opportunities

The impact of climate change on public health has gained significant attention, highlighting the urgent need for effective education strategies to address this complex challenge. Studies that have attempted to evaluate the knowledge on climate change, including aspects correlated to health, have found that, generally, the knowledge among school-aged children is low, where they have misconceptions regarding ozone and global warming and what their respective health effects are [65]. Similarly, adolescents’ knowledge was assessed specifically on climate change and health, and the results revealed that participants had a low and inconsistent understanding of the linkage between climate change and health [66].

However, there are some barriers that have been identified in terms of implementation. Gkatzos proposed the use of ICT in delivering climate change topics; however, the implementation of such an approach requires the training of both teachers and students [47]. In addition, confusion regarding the environmental theory that supports environmental education implementation is unclear, and this hinders teachers from implementing it in the classroom [67]. The barriers brought up by the included studies in this review were consistent with the general environmental education implementation barriers identified by the existing literature, including the complexity and ambiguity of EE and ESD along with the lack of time, space, and appropriate support from educational leaders being significant impediments for teachers [68]. Other barriers identified in terms of CCE implementation in formal education include low levels of enthusiasm by teachers [69] and the use of traditional teaching methods in environmental courses [70].

One cannot derive definite conclusions from the included studies in this review in terms of their effectiveness, as the studies were highly heterogeneous in their methodologies. In addition, the aim of this scoping review was to scope out the research in the climate and health domain and assess if a systematic review is feasible. However, the included studies that conducted intervention evaluations gave us more insights regarding the effectiveness of the programs. Five studies conducted intervention evaluations, and all of them concluded that the interventions were successful in reaching their goals. In particular, Kabir et al. (2015) [48] suggested that a school-based intervention for climate change and health adaptation was effective in increasing the knowledge level of school children on this topic. Likewise, Li et al. (2022) [50] found that a health education program focusing on heat in primary school was an effective approach to enhance the awareness and behavior of students and their parents in employing protective behaviors and enhancing their adaptation to heatwaves and climate change. Williams et al. (2017) [53] stated that young children were able to learn about flooding and preparedness as well as allow for intergenerational learning. Zhong et al. (2021) [54] found that classroom education had considerably positive effects on children's perceptions of flood risk. Bedoya et al. (2022) [55] concluded that their educational booklet and online conference on the management of vectors and VBDs resulted in significant differences between pre-test and post-test results.

Our review found that most of the studies focused on climate change and health adaptation, although it was hard to determine exactly what the focus was, as not all of the studies provided a detailed description of the content. Climate change adaptation is essential to respond to the increasing extreme weather/climate events that are projected to be more intense and extreme in the upcoming years. Such interventions may also be useful for other emergent occasions or public health emergencies, such as the control and prevention of COVID-19 [50]. However, both mitigation and adaptation strategies are necessary to minimize the health impacts of climate change [30], as mitigation efforts can have immediate health benefits by reducing emissions and by creating health co-benefits [33].

One benefit that was brought to attention by three of the included studies [50,53,54] was the intergenerational learning opportunity presented by climate change and health adaptation interventions or parent-child interactions as a mediating factor. Li et al.'s (2022) [50] results showed that a heat and health education program in primary school was an effective approach to improve the awareness and behavior of both students and their parents. Likewise, Williams et al.'s (2017) [53] flood education results revealed that intergenerational learning from child to parent can occur, with children transferring the messages learned in school to their homes. Likewise, Zhong (2021) [54] placed emphasis on considering risk-related parent-child interactions, which is an effective way to promote children's risk perception, thereby improving disaster resilience and climate change adaptation.

Li et al. also emphasized broader implications, expanding further than the parents and families. They stated that a "small hands holding big hands" (p. 11) approach used in health education programs for primary school students can have broader implications for improving the awareness and behavior of children and their families to adapt to heat waves and climate change. The study highlighted the importance of strengthening school health programs to prepare students for anticipated changes and to adapt to heat waves and climate change, which can contribute to a country's ability to successfully tackle and cope with the effects of climate change.

5. Limitations

It is important to note that our review may not have encompassed all articles published in every journal due to factors such as limited accessibility or the potential oversight of diverse terminology. Furthermore, the inclusion of only English language studies and articles poses a limitation, as it excludes evidence published in other languages. Another potential limitation is the lack of methodological quality appraisals conducted on the studies and the evidence included in the scoping review.

The exclusion of grey literature prevents a more comprehensive overview of the available evidence on climate change and health education. However, curricula and other grey literature were not included, as the aims of this review were to scope out the research in the climate health education field and gain insights regarding the focus of the topics and their effectiveness. This review also aimed to look at climate and health education with no geographical limits, and a comprehensive curricula analysis would have been unfeasible due to language and accessibility barriers.

6. Conclusions

This scoping review attempted to report the extensiveness of the literature on the relationship between climate change and health education in schools. The aim of this review was to assess the extent to which health topics have been incorporated into climate change education in primary and secondary schools as well as to analyze the nature of their inclusion. We explored five databases with relevant search strings. After reviewing the retrieved articles against the inclusion and exclusion criteria, nine articles were found to be fitting and were included in this review.

Generally, the included studies were heterogeneous in their methodologies and included various degrees of detail in terms of content and focus. The focus of the studies varied, however, and the majority of the studies (five out of nine) focused on climate change and health adaptation, particularly touching upon heatwave education, flood education, vector-borne diseases, and overall climate change and health adaptation. The rest of the studies focused on mitigation and a general conceptual understanding regarding the impacts of climate change on health.

Although the study designs were heterogeneous, the intervention evaluations concluded that the programs were successful in increasing the knowledge regarding the climate–health linkage. Additionally, the central role of schools was highlighted in promoting health and preparing children to be adaptation activists and impact knowledge, attitude, and perceptions to address climate change issues and reduce risks against adverse health outcomes.

While there is a growing body of research on the health impacts of climate change, more evaluations are necessary to understand the mechanisms behind their effectiveness as well as the barriers hindering their implementation, such as teacher capacity, teaching methods, complexity, and confusion among the concepts. Additionally, evaluations of these programs are necessary to assess their effectiveness and thereby develop effective educational strategies.

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