

# Oral Health in a Changing Climate: A Scoping Review of Global Evidence

Namrata Dagli<sup>1</sup> , Mainul Haque<sup>2,3,4,5</sup> 

Please  
Click on  
Photo



## ABSTRACT

Climate change is being recognized as a determinant of human health, yet its impact on oral health is underexplored. This scoping review aims to map the existing literature on the impact of climate change on oral health and dental practice and highlight key knowledge gaps. The literature search was conducted in the PubMed and Dimensions databases and supplemented by manual screening of the references of included studies. In total, 23 articles were included. Most of the articles published after 2019 reflect the field's emerging nature. The evidence indicates that climate change affects oral health through multiple direct and indirect pathways, including environmental and biological mechanisms. Vulnerable groups- children, older adults, low-income populations, rural communities, and those in low- and middle-income countries (LMICs) are identified as being at more substantial risk. The findings suggest that the field is in an early conceptual stage, characterized by narrative and opinion-based literature and limited empirical research. The evidence also suggests a bidirectional relationship: while climate change affects oral health and dental services, dental practice itself contributes to environmental burden. Although plausible pathways are well described, causal evidence remains scarce. This review highlights the need for interdisciplinary, empirical research, greater attention to under-studied regions, and integration of oral health into climate adaptation and sustainability policies.

## KEYWORDS

Climate change, oral health, dental diseases, environmental impacts, scoping review, sustainability, global warming, dentistry.

## INTRODUCTION

Climate change began during the Industrial Revolution in the mid-19th century, when atmospheric greenhouse gas concentrations began to increase due to the widespread use of fossil fuels<sup>1</sup>. Climate scientists consider 1850–1900 as a pre-industrial baseline, as most of the large-scale industrial emissions occurred after this period<sup>2</sup>. Since that time, global mean surface temperatures have increased steadily, with the rate of warming accelerating after the mid-20th century, driven by rapid industrialization, population growth, and increased energy consumption<sup>3</sup>. Climate change is characterized

1. Center for Global Health Research, Saveetha Medical College, Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai, India. Email: [dr.namrata.dagli@gmail.com](mailto:dr.namrata.dagli@gmail.com)
2. Department of Pharmacology, National Defense University of Malaysia, Kuala Lumpur, Malaysia. Email: [runurono@gmail.com](mailto:runurono@gmail.com)
3. Scientific Committee, Global Alliance for Infections in Surgery, Macerata, Italy.
4. Department of Pharmacology and Therapeutics, Eastern Medical College and Hospital, Cumilla, Bangladesh.
5. Public Health Foundation Bangladesh, Dhaka, Bangladesh.

## Correspondence

**Mainul Haque**

Independent Researcher. Block: C, Road: 10, House: 266, Level 2. Khilgaon, Dhaka 1219, Bangladesh. Email: [runurono@gmail.com](mailto:runurono@gmail.com). Cell Phone & WhatsApp: +8801 898943255, +8801 703605918

by rising global temperatures, more frequent extreme weather events, shifts in precipitation patterns, and deteriorating air and water quality. According to the Intergovernmental Panel on Climate Change (IPCC), the earth's surface temperature has risen in 2011–2020 by approximately 1.09°C above the pre-industrial level, with continuing increases expected over the coming decades<sup>3</sup>. Such environmental shifts have well-documented effects on general health<sup>4</sup>, including heat-related illnesses<sup>5</sup>, respiratory disease<sup>6,7</sup>, mosquito-borne diseases<sup>8</sup>, and viral infections<sup>9</sup>; however, the implications of climate change for oral health are relatively under-explored in the scientific literature<sup>10</sup>.

Oral diseases already contribute substantially to the global burden of disease, affecting approximately 3.5 billion people worldwide with conditions such as dental caries, periodontal disease, and oral cancers. These conditions disproportionately impact populations in low- and middle-income countries (LMICs) and socioeconomically disadvantaged communities, where access to dental care is limited<sup>11</sup>. While these oral health burdens are influenced by known risk factors such as diet, hygiene, and tobacco use, the effect of climate-related environmental stressors, such as heat stress, air pollution, water scarcity, food insecurity, and extreme weather events, remains comparatively underexplored and insufficiently integrated into oral health research and prevention strategies.

Although interest in the links between climate change and oral health is gradually increasing<sup>12</sup>, the evidence base remains underdeveloped and has not yet been comprehensively mapped. To date, only one scoping review has examined this topic, identifying 10 studies, with searches limited to 2024 across PubMed, Scopus, and Embase. By extending the search through 2025 across the PubMed and Dimensions databases, along with manual screening of the references of included articles, the present scoping review aims to provide an updated and broader overview of the impact of climate change on oral health and dental practice. The objectives include identifying the journals publishing in this field, the most common research themes, the geographical distribution, the types of publications, and the key findings and recommendations. The findings will reveal research gaps to inform future research and policy development.

## MATERIALS AND METHODS

### Study Design

This review was conducted to map the existing literature on the impact of climate change on oral health. A scoping review approach was selected because the field is emerging, interdisciplinary, and has diverse study designs. In addition, this approach was appropriate, as the purpose of the review was to describe the range of available evidence and identify research gaps rather than to conduct evidence synthesis. The review was conducted and reported in accordance with guidelines provided by the Joanna Briggs Institute (JBI) and PRISMA Extension for Scoping Reviews (PRISMA-ScR).

### Eligibility Criteria

Original research studies, review articles, editorials, and relevant perspective or policy-focused papers that addressed oral health outcomes or access to dental care in the context of climate-related exposures were included. No filter for language or publication year was applied.

Eligibility criteria were defined using the Population–Concept–Context (PCC) framework:

**Population:** Human populations of all age groups and sexes. Animal studies and articles not directly related to oral health were excluded.

**Concept:** In this scoping review, climate change was conceptualized as long-term changes in temperature, precipitation patterns, and the frequency of extreme weather events, along with their downstream impacts on environmental systems and human health. Studies focusing on the above-mentioned aspects were included. Ecological studies linking environmental indicators and the ecosystem to oral health outcomes were included if relevant to climate-related environmental conditions.

Laboratory-based microbial heat-stress studies without explicit linkage to climate or oral health outcomes were excluded. The studies focused solely on environmental pollution without explicit linkage to climate-related processes were excluded.

**Context:** Global, with no restriction on geographic location, income level, or healthcare setting.

### Databases and Search Strategy

A literature search was conducted in PubMed and Dimensions databases. The search strategy was crafted,

including relevant keywords related to climate change and oral health connected with appropriate Boolean operators. To ensure completeness, reference lists of included articles were manually screened to identify additional relevant studies. The following are the search strings used :

PubMed: (“climate change” OR “global warming” OR “climate variability” OR “extreme weather” OR “heat stress”) AND (“oral health” OR “dent\* health” OR “dentistry” OR “oral disease” OR “dent\* disease” OR “periodontal disease” OR “dental caries” OR “oral cancer” OR “dental care” OR “dent\* service”)

Dimensions: (“climate change” OR “global warming” OR “climate variability” OR “extreme weather” OR “heat stress”) AND (“oral health” OR “dental health” OR “dentistry” OR “oral disease” OR “dental disease” OR “periodontal disease” OR “dental caries” OR “oral cancer” OR “dental care” OR “dental service”)

### Study Selection

All identified records were imported into the Rayyan software for deduplication and screening. Two reviewers independently screened titles and abstracts to assess eligibility. Then, full-text screening was conducted for studies considered potentially relevant. Any disagreements between reviewers were resolved through discussion.

### Methodological Quality Appraisal

Since this scoping review aims to map the current evidence, we didn't conduct a risk-of-bias analysis. This approach is consistent with the scoping review guidelines (PRISMA-Scr)<sup>13,14</sup>.

### Data Extraction

A data-extraction form was developed and pilot tested. Extracted information included names of authors, title, abstract, year of publication, research themes, research design/publication type, country or region of study population (if any), key findings, and recommendations of the studies.

### Data Synthesis

Descriptive analysis was done. Study characteristics were summarized, and research gaps were identified based on areas with limited or absent research. Thematic patterns were observed, and plausible pathways linking the climate change and oral health were identified based on the existing literature and reported.

## RESULTS

### Search Results

A total of 614 records were retrieved from electronic databases, including PubMed (455) and Dimensions (159). Title and abstract screening of 461 records was conducted after removing 153 duplicates using Rayyan. Of these, 436 were excluded because the content was not related to the topic. Full texts of 25 articles were retrieved and assessed for eligibility. We identified 15 relevant articles from database screening after excluding 10 articles that focused solely on areas such as sustainable dentistry or heat stress.

We searched 896 references of selected articles to identify relevant articles not found directly from database searching and indexed in databases other than PubMed and Dimensions. After screening, we identified 17 articles; after full-text screening, 8 were found relevant to the topic. The other articles were excluded for reasons such as a focus on sustainable dentistry, lack of indexing in major databases, or treatment of natural disasters (e.g., earthquakes) without linking them to climate change. Finally, 23 studies met the inclusion criteria and were included in this scoping review. **Figure 1** illustrates the study selection process.

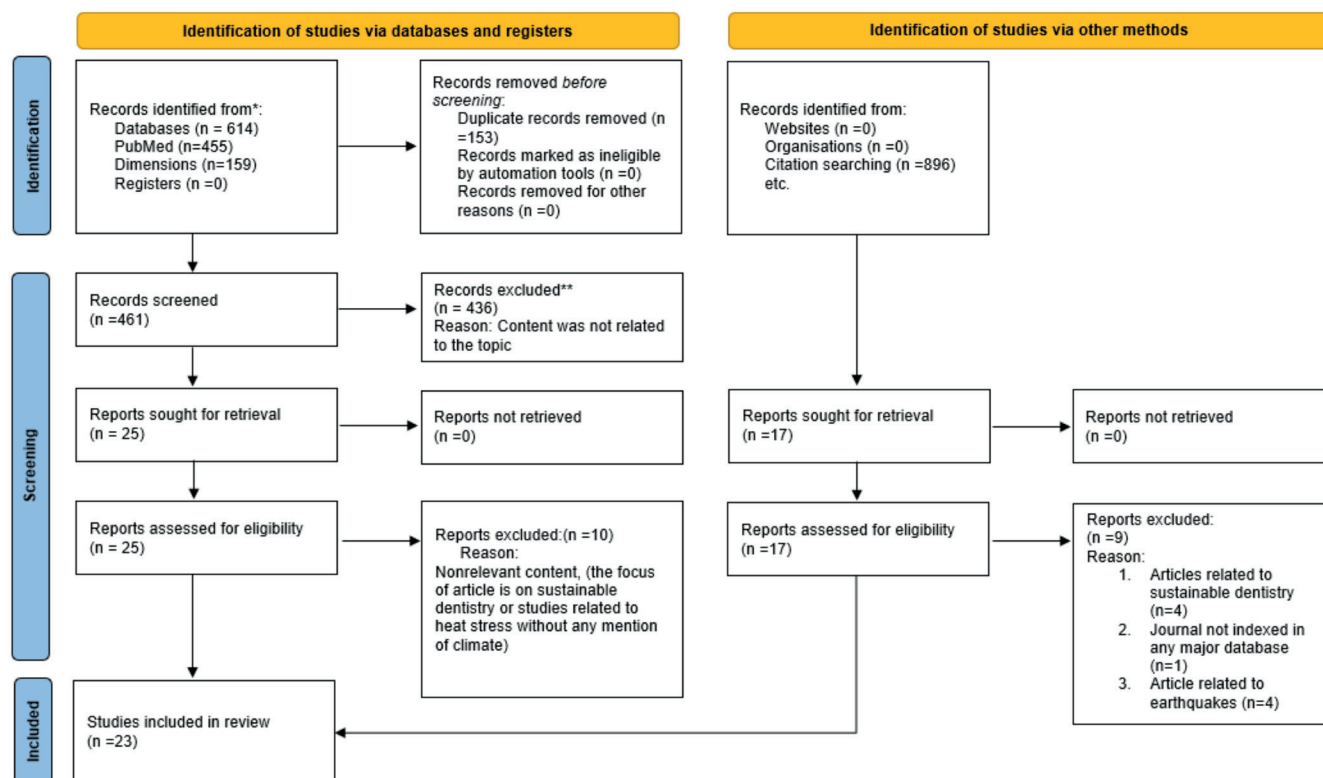
### Study Characteristics

#### Publication year

Although no filter was applied to the publication year, the 23 studies included in this scoping review were published between 2010 and 2025. The earliest publication was in 2010<sup>15</sup>, representing the only article from that year. Publication volume increased after 2019, with 2 studies published in 2019<sup>16,17</sup>, and 3 in 2020<sup>18-20</sup>. Most of the included studies (n=8) were published in 2024. Additionally, five studies were published in 2025<sup>21-25</sup>. This temporal distribution indicates a recent surge in research activity in this field, with approximately 74% (n=17) of the publications in the last 5 years (2021-2025).

#### Types of Articles

The included studies comprised various article types. Narrative reviews constituted the largest category, accounting for 7 studies<sup>15,22,23,25-28</sup>. Original research articles constituted the second most common category with 7 studies, encompassing various methodological approaches including a qualitative phenomenological study<sup>29</sup>, a large-scale observational study<sup>30</sup>, a



**Figure 1:** Flow chart depicting study selection process.

**Illustration Credit:** Namrata Dagli

randomized crossover experimental study<sup>18</sup>, one questionnaire study<sup>21</sup>, two ecological studies<sup>19,20</sup>, and one archaeological observational study<sup>16</sup>. Three scoping reviews were identified<sup>10,31,32</sup>. In contrast, other publications are opinion pieces or perspectives, including 2 editorials<sup>17,33</sup>, 2 letters to the editor<sup>34,35</sup>, 1 short communication<sup>24</sup>, and 1 commentary<sup>36</sup>.

#### Research Foci of Included Studies

Most of the included studies addressed the general impact of climate change on oral health outcomes, including dental caries, periodontal disease, oral cancer, enamel defects, and dental erosion<sup>22,23,25-27,36</sup>. Early childhood caries emerged as a particularly prominent area of inquiry, with four studies specifically investigating its relationship with climate-related factors, including greenhouse gas emissions, environmental performance indices, and ecosystem vitality<sup>19,20,31,32</sup>. Several articles explored the impact of climate change on dental practice and service accessibility during extreme weather events<sup>23,29,33,34</sup>. Additionally, unique perspectives were offered through investigations into sustainable dentistry practices<sup>24</sup>, the physiological effects of environmental

temperature on salivary parameters<sup>18</sup>, climate change impact on pediatric dentistry<sup>17</sup>, historical relationships between climate, diet, and dental caries through archaeological evidence<sup>16</sup>, impact of climate change in LMICs<sup>35</sup> and a KAP (Knowledge, Attitude and Practices) of dental students regarding the role of climate change in shaping dental practices<sup>21</sup>.

#### Geographic Region

Most studies (n=13) adopted a global perspective, not focusing on any specific geographic area; instead, they examined the relationships between climate change and oral health in a broadly applicable context<sup>10,17-20,22,24,25,28,31,32,36</sup>. South Asia emerged as a notable focus, with articles centered on India and the Indian subcontinent<sup>15,27</sup> and Pakistan, particularly Khyber Pakhtunkhwa<sup>24,29</sup>. Two studies examined the Chinese population: ancient northern Chinese communities<sup>16</sup> and modern fluoride-carries relationships in South and East China<sup>30</sup>. In one study, the discussion mainly focused on the United States while recognizing broader global implications<sup>33</sup>. Several studies discussed the vulnerability of LMICs to climate-related impacts on oral health<sup>23,24</sup>.

## Publishing Journals

The 23 included studies were published across a wide array of journals, reflecting the interdisciplinary nature of this emerging research area. The literature was distributed among dental specialties, public health, environmental science, and multidisciplinary journals. Dental-focused journals represented a significant portion of the publication venues, including *Oral Diseases*, *Journal of International Society of Preventive and Community Dentistry*, *The Journal of the American Dental Association*, *Journal of the California Dental Association*, *British Dental Journal Open*, *International Dental Journal*, *Acta Scientific Dental Sciences*,

*International Journal of Preventive and Clinical Dental Research*, *Edorium Journal of Dentistry*, *Archives of Oral Biology*, and *Journal of Global Oral Health*. Public health and biomedical journals such as *Cureus*, *BMC Oral Health*, *BMC Research Notes*, *Frontiers in Pediatrics*, *Discover Public Health*, and *Bioinformation* also contributed to the body of literature. Notably, some studies appeared in journals outside traditional dental or health sciences domains, including *PLOS ONE*, *Journal of Cleaner Production*, and the *International Journal of Environmental Science and Development*, indicating cross-disciplinary interest in this topic. Regional medical journals, such as the *Journal of the College*

**Table 1:** Characteristics of included studies

Serial No.	Author	Title	Type of Article	Research Focus	Journal	Key Finding	Recommendations
1	Cheung C et al. (2019)	Stable isotope and dental caries data reveal abrupt changes in subsistence economy in ancient China in response to global climate change	Archaeological observational study	Diet composition and dental caries due to climate change	PLOS ONE	The study combined carbon isotope evidence and dental caries data from 77 archaeological sites. It found that diets shifted from mainly millet-based foods to a more mixed diet around 4500 and 4000 BP. This change occurred during a period of increasing environmental dryness, suggesting that climate conditions may have influenced food choices and dental caries patterns.	Recommends integrating palaeodietary, climatic, and oral health data to understand how long-term climate stress alters diet and disease patterns.
2	Bokhari SS et al. (2021)	Invisible in the crisis: Community narratives on extreme weather and oral health inequities in Khyber Pakhtunkhwa, Pakistan	Original qualitative research article (Qualitative phenomenological study)	Access to dental care during climate-related extreme weather events in a low-resource setting	Preprint/ non-peer-reviewed research article	The study highlights systemic service breakdowns, financial and mobility barriers, and the absence of oral health in disaster preparedness.	Recommends climate-responsive oral health policies that prioritize vulnerable communities, integrate oral care into disaster preparedness, and address structural inequities amplified by extreme weather events.
3	Deshmukh CV et al. (2023)	Climate change on oral health and dentistry: Association and mitigation	Narrative Review	Influence of climate change on oral health outcomes and dental practice	Acta Scientific Dental Sciences	The article proposes that climate change affects oral health through heat-related dehydration, air pollution, water and food insecurity, disruptions to dental services caused by extreme weather, widening social inequities, and environmental impacts on dental practice.	Recommends incorporating climate mitigation and adaptation strategies into dental practice, public health planning, and professional education
4	Bhadauria US et al. (2025)	Impact of climate change on dentistry and oral health: A scoping review	Scoping Review	Climate change impact on oral health and dentistry	British Dental Journal Open	This scoping review identifies limited evidence on climate change and oral health that discusses direct/indirect associations of climate change with oral diseases and conditions such as dental caries, dental erosion, and oral cancer, developmental defects of enamel, early childhood caries, periodontal disease, and dental trauma, skeletal, and dental fluorosis.	The study recommends continued research and sustained policy attention.

Serial No.	Author	Title	Type of Article	Research Focus	Journal	Key Finding	Recommendations
5	Salarzai R et al. (2024)	The effects of climate change on oral health	Narrative Review	Influence of climate-related environmental stressors on oral health	Nangarhar University International Journal of Biosciences	The article summarizes existing concepts linking climate change, environmental conditions, and oral health outcomes, with emphasis on caries, oral cancer, and sustainability in dental care.	Emphasizes the need for public health preparedness, surveillance, and preventive strategies to address climate-driven changes in oral disease patterns, especially in low-resource settings.
6	Kemoli AM (2019)	Paediatric oral health and climate change	Editorial	Impact of climate change and environmental contamination on paediatric oral health and the role of paediatric dentistry in mitigation.	Edorium Journal of Dentistry	Climate affects enamel and nutrition	Recommends protecting child oral health through climate-resilient food systems, safe water access, and preventive dental care
7	Khanna S (2010)	Climate change & oral health: current challenges & future scope	Narrative Review	Impact of climate change on oral health, with emphasis on oral precancer/cancer and vulnerable populations.	International Journal of Environmental Science and Development	Climate change impacts oral health through multiple pathways, including environmental degradation, malnutrition, infectious diseases, and increased risk of oral precancer and cancer. Vulnerable populations (children, geriatric individuals, rural and low-income groups) are disproportionately affected.	Calls for strengthened epidemiological research, health system readiness, preventive programmes, and policy investment to mitigate climate-related oral diseases, particularly in vulnerable populations.
8	Patil VS et al (2023)	Addressing the impact of the climate crisis on oral health	Narrative Review	Impact of environmental and socio-economic changes caused by the climate crisis on oral diseases	International Journal of Preventive and Clinical Dental Research	Changes in temperature, humidity, precipitation patterns, and food availability affect oral health, increasing the risk of oral diseases and conditions, including dental caries, oral cancer, and periodontal disease, and dental erosion. Nutrition also gets affected	upgrading health-care facilities and research support
9	Zhou L et al (2024)	Overlooked fluorine deficiency exacerbated by climate change	Original Research (Large-scale observational study)	Association among climate change, fluoride concentration in water, and dental caries	Journal of Cleaner Production	Climate change may exacerbate fluorine deficiency in children in South and East China.	
10	Hackley DM (2021)	Climate change and oral health	Commentary	Clinical implications of climate change for oral health	International Dental Journal	Climate change exposure pathways—including heat stress, air pollution, food and water insecurity, extreme events, vector-borne diseases, social disruption, mental stress, and pandemics—are collectively associated with increased risk of dental caries, periodontal disease, oral trauma, developmental defects, infections, and disrupted access to oral healthcare.	Resilient health care system and preparedness for adverse climate events to ensure positive health outcomes, particularly for the vulnerable population.
11	Geetha GMN et al (2025)	A narrative review on the multifaceted impacts of climate change on oral health	Narrative Review	Oral health challenges due to climate change	Discover Public Health	The existing literature indicates that climate-related factors are associated with a range of oral health outcomes, including dental caries, periodontal disease, enamel defects, oral cancer, and dental trauma. In addition, several studies highlight climate-related disruptions to oral healthcare delivery systems and increases in operational and service-related costs.	Emphasized developing policy frameworks for the integration of oral health into climate adaptation planning. In addition, recommends curriculum reform and coordinated action across research, policy, education, and clinical practice.

Serial No.	Author	Title	Type of Article	Research Focus	Journal	Key Finding	Recommendations
12	Francis DL et al (2024)	Climate change and oral health: Assessing the impacts and developing strategies for adaptation	Letter to Editor	Implications of climate change for oral health and outlining adaptive strategies for dental practice and public health systems.	Oral Diseases	full text not available	
13	Qamar W et al (2024)	Understanding the Impact of Climate Change in Lower- and Middle-Income Countries.	Letter to the Editor	Impact of climate change in Lower- and Middle-Income Countries	Journal of the College of Physicians and Surgeons Pakistan	The article discusses the indirect effect of climate change on oral health in lower-middle-income countries, particularly in vulnerable populations.	climate-resilient healthcare system
14	Selvan P et al (2025)	The impact of climate change on oral health - A multifaceted perspective	Narrative Review	Climate-related oral dysbiosis and disruption of oral healthcare delivery.	Journal of Global Oral Health	Climate change affects oral health by altering saliva, diet, microbial balance, immunity, and access to care, thereby increasing the risk of caries, periodontal disease, enamel defects, oral cancer, and oral-systemic inflammation.	Educating patients and policymakers on climate-oral health links and integrating sustainability into dental curricula
15	Hu N et al (2024)	Impacts of climate change on oral health and dentistry - Why should dentists care and what can they do?	Narrative Review	Climate change and oral health interrelationship	Journal of the California Dental Association	Climate change impacts oral health both directly – through extreme weather events – and indirectly – via increased allergies, air pollution, food and water insecurity, vector-borne illness, and mental health issues.	Emphasize sustainability in dental practices, patient education, and collaboration among policymakers, dental practitioners, and vendors to improve both environmental health and patient well-being.
16	Ligtenberg AJ et al (2020)	Effects of environmental temperature on saliva flow rate and secretion of protein, amylase, and mucin 5B.	Original research (Randomized crossover experimental study)	Effects of environmental temperature on saliva flow rate and composition	Archives of Oral Biology	Saliva flow rate increases with decreasing temperature, even after a short 10 min exposure. Exposure to cold (4 °C) increases saliva protein secretion.	Recommends future studies with larger sample sizes and suggests further investigation into physiological mechanisms, including hydration status and core body temperature
17	Licari FW and Patil S (2024)	Climate change and the unforeseen challenges for dental practice.	Editorial	Impact of climate change on dental practice	The Journal of the American Dental Association.	The editorial discusses how climate change-driven extreme weather and rising insurance risks threaten the financial stability, infrastructure, and accessibility of dental care services.	Recommends the sustainability of dental practices and to ensure uninterrupted and affordable oral health care for patients.
18	Folayan MO et al (2020)	An ecological study of the association between environmental indicators and early childhood caries	Original research (Ecological study)	Greenhouse gas emissions and early childhood caries	BMC Research Notes	The study revealed that methane and nitrous oxide Emission intensities were risk indicators for early childhood caries.	The article recommends strengthening climate-resilient and sustainable dental practices, revising insurance and policy frameworks, and adopting mitigation strategies to ensure continuity, affordability, and accessibility of oral health care amid climate-related disruptions.
19	Folayan MO et al (2024)	Early childhood caries, climate change, and the Sustainable Development Goal 13: a scoping review.	Scoping Review	Climate change and early childhood caries	BMC Oral Health.	Climate change may increase the Risk for caries and the current early childhood caries management techniques may increase environmental degradation. The study discusses strategies that can reduce the negative impact of early childhood caries management on the environment.	Recommendations include adopting context-specific, environmentally sustainable caries prevention and management strategies to reduce both early childhood caries burden and the environmental impact of pediatric dental care.

Serial No.	Author	Title	Type of Article	Research Focus	Journal	Key Finding	Recommendations
20	Foláyan MO et al (2020)	Association between environmental health, ecosystem vitality, and early childhood caries	Original research (Ecological cross-sectional study)	Environmental health, ecosystem, and early childhood caries	Frontiers in pediatrics	The study found inverse but statistically non-significant associations between early childhood caries prevalence and both the Environmental Performance Index and ecosystem vitality, alongside a direct association between early childhood caries and environmental health.	The authors recommend integrating environmental protection and ecosystem sustainability into public health and oral health strategies
21	Kalra G et al (2024)	Assessing the impact of climate change on early childhood caries within the framework of Sustainable Development Goal 13: A scoping review	Scoping Review	ECC and climate change	Cureus	Recent reviews indicate a potential link between climate change and dental health outcomes, including childhood caries. Still, current evidence is insufficient to confirm a clear association, highlighting the need for further robust studies.	The review recommends integrating sustainable developmental strategies and eco-friendly preventive measures in pediatric dentistry. Additionally, authors recommend developing specialized courses or curricula centered on sustainable dental practices
22	Shrivastava, S. R. et al (2025)	Oral health and climate change: Working toward adaptive strategies to the changing environment	Short Communication	Climate change impact on oral health and Strategies for Climate-Adaptive Oral Health Care	Journal of the International Society of Preventive and Community Dentistry	Climate change has increased the risk of many oral diseases, including periodontal diseases, dental caries, and oral cancers, particularly in climate-vulnerable regions.	Recommends sustainable dental care practices, promotes climate-resilient dental practice, and educates vulnerable populations. Additionally, the author emphasizes the incorporation of oral healthcare initiatives into climate adaptation strategies.
23	Gupta HB et al (2025)	A KAP-based evaluation on the role of climate change in shaping dental practices	Original research (cross-sectional KAP study)	Dental workforce response to climate change and sustainability in dental practice	Bioinformation	Even when awareness about the impact of climate change on oral health exists, practice and institutional support are lacking.	Authors recommend curriculum reform and institutional policy support to promote sustainable and climate-responsive dental practices.

of Physicians and Surgeons Pakistan and Nangarhar University International Journal of Biosciences, further expanded the publication landscape (Table 1).

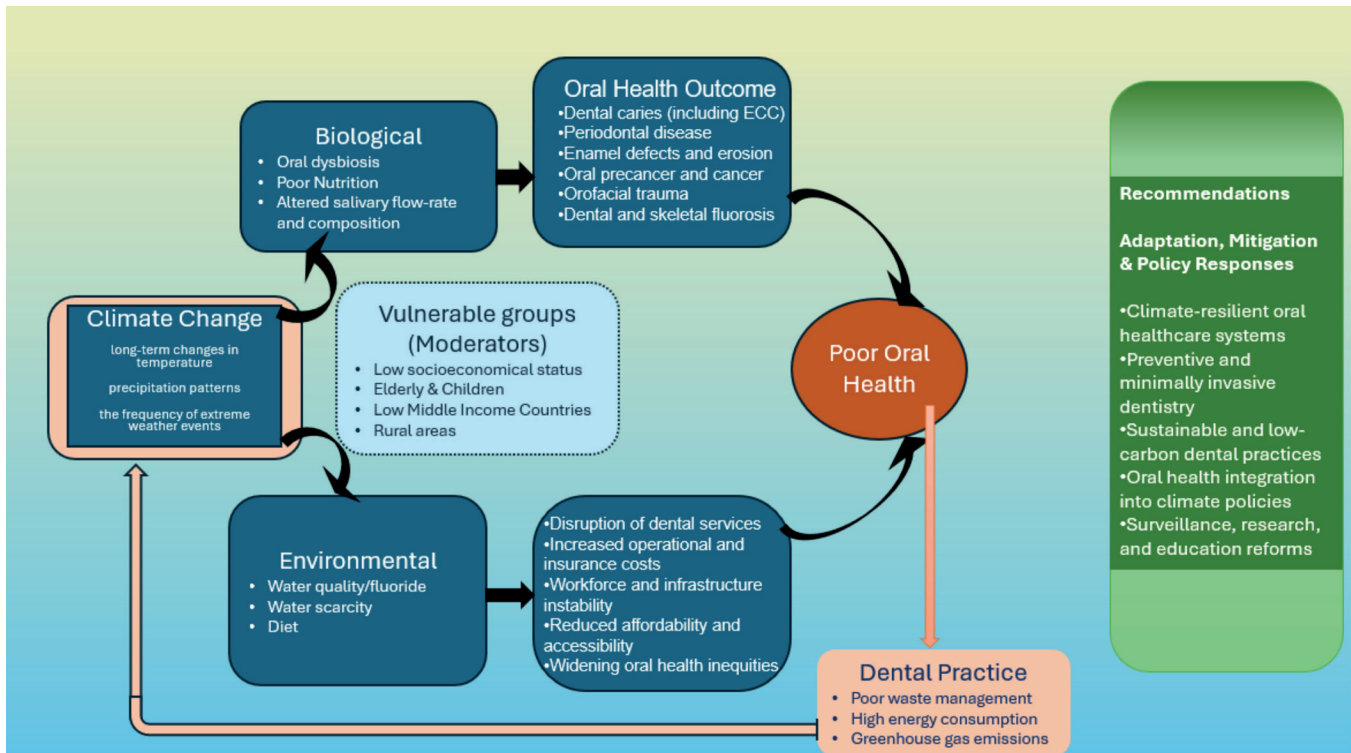
### Thematic Patterns

Despite the heterogeneity in study designs and research foci, several consistent themes emerged from the included literature, illustrated in a conceptual pathway framework linking climate change and oral health (Figure 2).

### Climate–Oral Health Pathways

Based on the included studies' data, climate change influences oral health through direct and indirect pathways, primarily through biological and environmental factors. Biological pathways operate primarily indirectly, through heat-related dehydration that affects salivary function, air pollution that damages oral tissues, and nutritional changes that influence tooth development

and disease risk. Additionally, it may alter fluoride concentrations in water sources, thereby affecting caries prevalence. Environmental pathways include extreme weather events that directly cause physical trauma and indirectly alter air quality, water availability, food security, and fluoride levels in drinking water. In addition, environmental pathways include the direct disruption of dental services by floods, heatwaves, and disasters, as well as indirect effects through reduced access, financial strain, and weakened health-system capacity<sup>23-25,30,36</sup>. A study also discussed that climate-related oral dysbiosis might affect oral health<sup>23</sup>. The experimental study by Ligtenberg et al. (2020)<sup>18</sup> provided physiological evidence that environmental temperature directly influences saliva flow rate and protein secretion, with colder temperatures increasing salivary output. Studies examining early childhood caries identified potential associations with greenhouse



**Figure 2:** Conceptual pathway framework illustrating how climate change influences oral health outcomes through direct and indirect pathways.

**Illustration Credit:** Namrata Dagli

gas emissions, environmental health indices, and ecosystem degradation. However, statistical significance was not consistently achieved, indicating the need for further investigation<sup>19,20</sup>. The archaeological study by Cheung et al. (2019) presented historical evidence that climate-driven dietary shifts were associated with changes in dental caries patterns<sup>16</sup>.

### Vulnerability and Inequity

Another theme identified across studies is the vulnerability of the population. Many studies have emphasized that the oral health impacts of climate change are not evenly distributed. Children, older adults, low-income groups, rural populations, and communities in LMICs were identified as being at higher risk. Climate change may exacerbate existing inequities by limiting access to food, clean water, and healthcare<sup>15,29,35</sup>.

### Environmental Impact of Dental Practice

Another recurring theme was the bidirectional relationship between dentistry and climate change. Not only does climate change affect oral health, but dental

care also affects the climate through energy use, poor waste management, and green gas emissions. Few studies have recommended preventive, minimally invasive approaches to reduce the impact of dental practices on the climate and environment<sup>24,28,32</sup>.

### Reported Recommendations

The included studies recommend integrating oral health into climate-related policies<sup>22,29,36</sup>; practicing green dentistry<sup>24,25,28,32</sup>; preventive and minimally invasive care<sup>17,31</sup>; making dental care climate-resilient<sup>29,35,36,37</sup>; climate adaptation planning in the oral health care system<sup>22,25</sup>, and curriculum reform and professional education<sup>21,22,23,25</sup>. These articles collectively recommend system-level action rather than relying solely on clinical interventions.

## DISCUSSION

The field has started gaining attention, particularly over the past five years. Climate change has been recognized as a critical determinant of oral health across the studies<sup>36</sup>. This trend aligns with broader patterns in global

health scholarship, in which climate change has been recognized as an important determinant of health outcomes across multiple domains<sup>10,38</sup>. The literature includes various study types: original research, ecological and experimental studies, archaeological and historical analyses, narrative and scoping reviews, editorials, commentaries, and letters to the editor. Most publications were conceptual or opinion-based, with very few empirical studies. This reflects an early stage of conceptual development. The studies addressed diverse topics, e.g., physiological experiments on salivary function<sup>18</sup> and ecological analyses of early childhood caries<sup>19,20</sup>.

The journals publishing these studies indicate the interdisciplinary interest in this topic, with contributions from dentistry, public health, environmental science, and even archaeology. Most studies adopted a global lens, while region-specific investigations were concentrated in South Asia, China, and Pakistan. Notably absent were empirical studies from high-income Western countries, Africa, and South America.

The research foci of the included studies reveal that much of the literature examined climate change as a broad determinant of oral health outcomes. The studies proposed plausible pathways linking climate change to oral conditions such as dental caries, periodontal disease, and oral cancer<sup>10,22</sup>. Early childhood caries has been examined in multiple studies that have sought to correlate climate-related indicators, such as greenhouse gas emissions and ecosystem vitality, with caries prevalence<sup>19,20,31,32</sup>.

The focal theme identified was direct and indirect climate-oral health pathways, primarily biological and environmental pathways. These pathways were influenced through moderators such as social, economic, and geographical factors, especially in LMICs<sup>39</sup>. Furthermore, environmental pathways indirectly affect oral health care via extreme weather events, which disrupt healthcare service delivery<sup>29,33</sup>. This aligns with recent calls to integrate oral health into planetary health frameworks, recognizing the mouth as both a site of disease and a reflection of systemic vulnerabilities<sup>40</sup>.

Another essential theme is the vulnerable population and the environmental impact of dental practice. These findings resonate with broader evidence that climate change disproportionately affects LMICs, where adaptive capacity is limited and oral health services are often under-resourced<sup>11</sup>. The studies also pointed

towards a bidirectional relationship between dentistry and climate change. While oral health is vulnerable to climate-related challenges, dental practices contribute to environmental degradation through excessive energy consumption, poor waste management, and greenhouse gas emissions, creating a feedback loop<sup>28,32</sup>. The studies recommend developing sustainable dentistry models to reduce ecological footprints and enhance resilience.

Our literature search identified one prior scoping review on this topic. However, there is notable variation in the volume of identified literature<sup>10</sup>. The article included 10 articles indexed in the PubMed, Embase, and Scopus databases. In contrast, our review identified 23 relevant studies. The discrepancy in the number of included articles likely stems from variations in the search strings, publication periods, and database selection, as well as from the addition of a comprehensive manual reference exploration phase in our review. Furthermore, the study selection process might be influenced by the subjective judgment of authors.

### Strengths of This Paper

A comprehensive search strategy was employed, including rigorous manual screening of references and data extraction from two online databases. Utilization of two databases, PubMed and Dimensions, ensured inclusion of literature across dentistry, public health, environmental science, and related fields. Additionally, screening the references of included articles identified relevant studies indexed in databases other than the two used.

### Limitations of This Paper

Certain limitations must be acknowledged. Restricting the search to PubMed and Dimensions might have excluded relevant studies indexed in other specialized databases such as Scopus, Web of Science, or Embase. Although exploring the reference list helped mitigate this limitation, reliance on available citations might introduce bias toward more accessible studies. Furthermore, the quality assessment of studies was not done, as the focus was on mapping the literature.

### Research Gap and Future Study Recommendations

Findings suggest that empirical research from high-income Western countries, African nations, and South American regions is lacking. Future research should focus on empirical studies to test the plausible pathways proposed and establish causal relationships. In addition, underrepresented areas such as Africa,

South America, and high-income Western countries need to be included to capture diverse vulnerabilities and enable the development of effective adaptive strategies. Interdisciplinary collaborations between dental researchers, climate scientists, and public health practitioners are essential to make oral healthcare more climate-resilient and sustainable. Additionally, research should focus on how to effectively integrate oral health into climate-related policies.

## CONCLUSIONS

The findings indicate that the literature on climate change and oral health is scarce. It remains at an early conceptual stage and has begun to gain attention, particularly in the last 5 years. Most of the literature consists of opinion pieces and narrative reviews, with few empirical articles. While many publications describe plausible pathways linking climate change to oral diseases directly or indirectly, there is limited empirical evidence to confirm causal relationships. While most of the evidence is not region-specific, the few studies were limited to India, Pakistan, and China. The main themes identified were climate change influences oral health through direct and indirect biological and environmental pathways, vulnerable populations, and environmental burden caused by dental practice. The literature was published in dental specialty, public health, environmental science, and multidisciplinary journals, indicating the interdisciplinary nature of the field. Studies also highlight that dentistry itself contributes to environmental degradation, underscoring the need for sustainable models of care. Taken together,

these findings highlight oral health as both a victim and contributor. Our study calls for urgent, coordinated action to strengthen resilience, equity, and sustainability in dental research and practice.

## Consent for Publication

The author has reviewed and approved the final version and agrees to be accountable for all aspects of the work, including any accuracy or integrity issues.

## Disclosure

Mainul Haque is a member of the editorial team of the Bangladesh Journal of Medical Science. The rest of the authors declare that they do not have any financial involvement or affiliations with any organization, association, or entity directly or indirectly related to the subject matter or materials presented in this review paper.

## Data Availability

Information for this review paper is taken from freely available sources.

## Authorship Contribution

All authors contributed significantly to the work, whether in the conception, design, utilization, collection, analysis, or interpretation of data, or all these areas. They also participated in the paper's drafting, revision, or critical review, gave their final approval for the version that would be published, decided on the journal to which the article would be submitted, and made the responsible decision to be held accountable for all aspects of the work.

## REFERENCES

- Intergovernmental Panel on Climate Change. Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press; 2021. doi:10.1017/9781009157896.
- Intergovernmental Panel on Climate Change. Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II, and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva: IPCC; 2023. Available from: <https://www.ipcc.ch/report/ar6/syr/> [Accessed January 29, 2026]
- Intergovernmental Panel on Climate Change (IPCC). Summary for Policymakers. In: Climate Change 2021 – The Physical Science Basis: Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press; 2023:3-32. Available from [https://www.cambridge.org/core/services/aop-cambridge-core/content/view/8E7A4E3AE6C364220F3B76A189CC4D4C/9781009157889pre2\\_3-32.pdf/summary-for-policymakers.pdf](https://www.cambridge.org/core/services/aop-cambridge-core/content/view/8E7A4E3AE6C364220F3B76A189CC4D4C/9781009157889pre2_3-32.pdf/summary-for-policymakers.pdf) [Accessed January 29, 2026]
- Campbell-Lendrum D, Neville T, Schweizer C, Neira M. Climate change and health: three grand challenges. *Nat Med*. 2023;**29**(7):1631-1638. doi: 10.1038/s41591-023-02438-w.
- O'Connor FG. Heat-Related Illnesses. *Ann Intern Med*. 2025;**178**(7):ITC97-ITC112. doi: 10.7326/ANNAALS-25-01958.
- D'Amato G, D'Amato M. Climate change, air pollution, pollen allergy, and extreme atmospheric events. *Curr Opin Pediatr*. 2023;**35**(3):356-361. doi: 10.1097/MOP.0000000000001237.
- Eguiluz-Gracia I, Mathioudakis AG, Bartel S, Vijverberg SJH, Fuertes E, Comberiat P, Cai YS, Tomazic PV, Diamant Z, Vestbo J, Galan C, Hoffmann B. The need for clean air: The way air pollution and climate change affect allergic rhinitis and asthma. *Allergy*. 2020;**75**(9):2170-2184. doi: 10.1111/all.14177.
- Carreto C, Gutiérrez-Romero R, Rodríguez T. Climate-driven mosquito-borne viral suitability index: measuring risk transmission of dengue, chikungunya and Zika in Mexico. *Int J Health Geogr*. 2022;**21**(1):15. doi: 10.1186/s12942-022-00317-0.
- Gamarra H, Carhuapoma P, Cumapa L, González G, Muñoz J, Sporleder M, Kreuze J. A temperature-driven model for potato yellow vein virus transmission efficacy by *Trialeurodes vaporariorum* (Hemiptera: Aleyrodidae). *Virus Res*. 2020;**289**:198109. doi: 10.1016/j.virusres.2020.198109.
- Bhadauria US, Purohit B, Giraudeau N, Atri M, Priya, H. Impact of climate change on dentistry and oral health: A scoping review. *BDJ Open*. 2025; **11**: 32. Available from <https://doi.org/10.1038/s41405-025-00310-2> [Accessed January 21, 2026]
- GBD 2021 Oral Disorders Collaborators. Trends in the global, regional, and national burden of oral conditions from 1990 to 2021: a systematic analysis for the Global Burden of Disease Study 2021. *Lancet*. 2025;**405**(10482):897-910. doi: 10.1016/S0140-6736(24)02811-3.
- Fejerskov O, Uribe S, Mariño RJ. Dentistry in a historical perspective and a likely future of the profession. In (Eds): Mariño R, Morgan M, Walmsley A, editors. Career paths in oral health. Cham: Springer; 2018:1–20. doi:10.1007/978-3-319-89731-8\_1.
- Peters MD, Godfrey CM, Khalil H, McInerney P, Parker D, Soares CB. Guidance for conducting systematic scoping reviews. *Int J Evid Based Healthc*. 2015;**13**(3):141-6. doi: 10.1097/XEB.0000000000000050.
- Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, Moher D, Peters MDJ, Horsley T, Weeks L, Hempel S, Akl EA, Chang C, McGowan J, Stewart L, Hartling L, Aldcroft A, Wilson MG, Garrity C, Lewin S, Godfrey CM, Macdonald MT, Langlois EV, Soares-Weiser K, Moriarty J, Clifford T, Tunçalp Ö, Straus SE. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Ann Intern Med*. 2018;**169**(7):467-473. doi: 10.7326/M18-0850.
- Khanna S. Climate Change & Oral Health: Current Challenges & Future Scope. *Int J Environ Sci Develop*. 2010;**1**(2):190. DOI: 10.7763/IJESD.2010.V1.35
- Cheung C, Zhang H, Hepburn JC, Yang DY, Richards MP. Stable isotope and dental caries data reveal abrupt changes in subsistence economy in ancient China in response to global climate change. *PLoS One*. 2019;**14**(7):e0218943. doi: 10.1371/journal.pone.0218943.
- Kemoli AM. Pediatric oral health and climate change. *Edorium J Dent*. 2019;**7**(100034):D01AK2019. doi: 10.5348/100034D01AK2019ED
- Ligtenberg AJM, Meuffels M, Veerman ECI. Effects of environmental temperature on saliva flow rate and secretion of protein, amylase, and mucin 5B. *Arch Oral Biol*. 2020;**109**:104593. doi: 10.1016/j.archoralbio.2019.104593.
- Folayan MO, Tantawi ME, Gaffar B, Schroth RJ, Catillo JL, Al-Batayneh OB, Kemoli A, Díaz ACM, Pavlic V, Raswhan M, Group FECCA. An ecological study of the association between environmental indicators and early childhood caries. *BMC Res Notes*. 2020;**13**(1):474. doi: 10.1186/s13104-020-05321-w.
- Folayan MO, El Tantawi M, Schroth RJ, Kemoli AM, Gaffar B, Amalia R, Feldens CA; ECCAG. Association Between Environmental Health, Ecosystem Vitality, and Early Childhood Caries. *Front Pediatr*. 2020;**8**:196. doi: 10.3389/fped.2020.00196.
- Gupta HB, Sarangi S, Mutha R, Sutar MB, Ponnukumar A, Karande V, Kashwani R. A KAP-based evaluation on the role of climate change in shaping dental practices. *Bioinformation*. 2025;**21**(6):1416-1420. doi: 10.6026/973206300211416.
- Geetha GMN, Gupta M, Ahamed S, Yaseen I, Mohan R. A narrative review on the multifaceted impacts of climate change on oral health: a call for sustainable practices. *Discov Public Health*. 2025; **22**: 801. Available from <https://doi.org/10.1186/s12982-025-01194> [Accessed January 20, 2026]
- Selvan P, Thavarajah R, Ranganathan K. The impact of climate change on oral health - a multifaceted perspective. *J Global Oral Health*. 2025;**8**(2):98-106. doi:10.25259/JGOH\_15\_2025.

24. Shrivastava SR, Bobhate PS, Kukde M. Oral Health and Climate Change: Working Toward Adaptive Strategies to the Changing Environment. *J Int Soc Prev Community Dent.* 2025;**15**(2):192-195. doi: 10.4103/jispcd.jispcd\_228\_24.
25. Deshmukh CV, Dodamani AS, Mistry VD. Climate change on oral health and dentistry: association and mitigation. *Acta Sci Dental Sci.* 2023;**7**(1). doi: 10.31080/ASDS.2023.07.1538
26. Riaz S, Abdullah R, Sadat M, Naveedullah Z. The Effects of Climate Change on Oral Health. *Nangarhar Uni Int J Biosc.* 2024; **3** (02):89-92. Available from <https://nuijb.nu.edu.af/index.php/nuijb/article/view/174/115> [Accessed January 21, 2026]
27. Patil VS. Addressing the impact of the climate crisis on oral health. *Int J Prev Clin Dent Res.* 2023;**10**(1):20-2. doi: 10.4103/ijpcdr.ijpcdr\_6\_23
28. Hu NH. Why Should I, as a Dentist, Care About Climate Change? *J Calif Den Assoc.* 2024;**52**(1):2428204. doi: 10.1080/19424396.2024.2428204
29. Bokhari SS, Khattak SI, Alsabaani A, Douglas G, Haq ZU, Khattak MI. Invisible in the crisis: community narratives on extreme weather and oral health inequities in Khyber Pakhtunkhwa, Pakistan. *Research Square;* 2025. Available from: <https://doi.org/10.21203/rs.3.rs-7304819/v1> [Accessed January 20, 2026]
30. Zhou L, Liang W, Meng Y, Zhao X, Guo F, Liu L, Wenjing L, Teng M, Song F, Cao Z, Mi Y, Lin Q, Liu S, Abbaspour KC, Wu F. Overlooked fluorine deficiency in children of South and East China may be exacerbated by climate change: evidence from the national assessment. *J Clean Prod.* 2024;**434**:140128. doi:10.1016/j.jclepro.2023.140128.
31. Kalra G, Nangia T, Kumar Y. Assessing the Impact of Climate Change on Early Childhood Caries Within the Framework of Sustainable Developmental Goal 13: A Scoping Review. *Cureus.* 2024;**16**(10):e71872. doi: 10.7759/cureus.71872.
32. Foláyan MO, Schroth RJ, Abodunrin O, Al-Batayneh OB, Arheiam A, Mfolo T, Virtanen JI, Duangthip D, Feldens CA, El Tantawi M. Early childhood caries, climate change and the sustainable development goal 13: a scoping review. *BMC Oral Health.* 2024;**24**(1):524. doi: 10.1186/s12903-024-04237-2.
33. Licari FW, Patil S. Climate change and the unforeseen challenges for dental practice. *J Am Dent Assoc.* 2024;**155**(3):191-192. doi: 10.1016/j.adaj.2023.12.005.
34. Francis DL, Reddy SSP, Logaranjani A, Chopra SS. Climate change and oral health: Assessing the impacts and developing strategies for adaptation. *Oral Dis.* 2024;**30**(7):4792-4793. doi: 10.1111/odi.14922.
35. Qamar W, Qayum M. Understanding the Impact of Climate Change on Oral Health in Lower Middle-Income Countries. *J Coll Physicians Surg Pak.* 2024;**34**(4):499. doi: 10.29271/jcpsp.2024.04.499. PMID: 38576299.
36. Hackley DM. Climate Change and Oral Health. *Int Dent J.* 2021;**71**(3):173-177. doi: 10.1111/idj.12628.
37. Hartinger SM, Palmeiro-Silva YK, Llerena-Cayo C, Blanco-Villafuerte L, Escobar LE, Diaz A, Sarmiento JH, Lescano AG, Melo O, Rojas-Rueda D, Takahashi B, Callaghan M, Chesini F, Dasgupta S, Posse CG, Gouveia N, Martins de Carvalho A, Miranda-Chacón Z, Mohajeri N, Pantoja C, Robinson EJZ, Salas MF, Santiago R, Sauma E, Santos-Vega M, Scamman D, Sergeeva M, Souza de Camargo T, Sorensen C, Umaña JD, Yglesias-González M, Walawender M, Buss D, Romanello M. The 2023 Latin America report of the Lancet Countdown on health and climate change: the imperative for health-centred climate-resilient development. *Lancet Reg Health Am.* 2024;**33**:100746. doi: 10.1016/j.lana.2024.100746.
38. Allen EM, Munala L, Frederick AJ, Quito C, Enayat A, Ngunjiri ASW. Climate Change and Health: Impacts Across Social Determinants in Kenyan Agrarian Communities. *Climate.* 2025; **13**(8):169. Available from <https://doi.org/10.3390/cli13080169> [Accessed January 21, 2026]
39. Folayan MO, Obiyan MO, El Tantawi M, Kemoli A, Al-Batayneh OB, Gaffar B, Schroth RJ; Early Childhood Caries Advocacy Group. An ecological study on the association between early childhood caries and intimate partner violence in 20 low- and middle-income countries: 2007-2017. *AAS Open Res.* 2022;**4**:39. doi: 10.12688/aasopenres.13237.3.
40. Peres MA, Macpherson LMD, Weyant RJ, Daly B, Venturelli R, Mathur MR, Listl S, Celeste RK, Guarnizo-Herreño CC, Kearns C, Benzian H, Allison P, Watt RG. Oral diseases: a global public health challenge. *Lancet.* 2019;**394**(10194):249-260. doi: 10.1016/S0140-6736(19)31146-8.