

Review Article

Impacts of Climate Change on Health: A Current Assessment

ABSTRACT

Climate change refers to an accelerated change in climate that is directly or indirectly attributed to human activities, altering the composition of the global atmosphere and occurring in addition to the natural climate variability observed over comparable periods. This change is one of the most critical global challenges of the 21st century, creating impacts in many environmental, social and economic dimensions. It is known that environmental effects play an essential role in the development of diseases as well as genetic predisposition. According to the World Health Organisation, human health is directly and indirectly affected by the spread of infectious diseases due to increasing global temperature and extreme weather events, deterioration of air quality and endangering water and food safety. The health sector must actively participate in climate change adaptation and mitigation strategies in this context. To better understand the effects on health and to evaluate them as a whole, 60 of the literature reached as a result of the systematic literature review was included in the review prepared within the scope of the study. More research and a more comprehensive global policy are needed to fully understand and cope with the effects of climate change on human health. Social awareness about the impact of extreme weather temperature changes, especially in the groups attributed to the risk group, should be raised in health centers.

Keywords: Climate change, human, health, World Health Organization.

1. INTRODUCTION

Climate change refers to an accelerated change in climate, apart from the natural climate variability observed over comparable periods, directly or indirectly attributed to human activities, altering the atmosphere's composition (1). According to the World Health Organization (WHO), climate change directly or indirectly affects human health with causes

such as the spreading of infectious diseases due the increased global temperature and extreme weather events, deterioration of air quality, and endangering of water and food safety (2).

It has been stated that the past 8 years have been the hottest years ever. Extreme weather events observed on every continent were reported in 2022. The extremely hot summer caused the death of approximately 62 thousand people in Europe in 2022, the extreme floods affected approximately 3 million people in Nigeria and 33 million people in Pakistan in the same year. In Africa, droughts exacerbated by climate change have also been reported to deteriorate food safety. Also it was reported that some regions of Europe, South America, and China faced forest fires (3).

Climate change causes both short-term and long-term effects on health (4). With these effects, the incidence of various health problems, including infectious and non-infectious diseases, is increasing on a global scale (5). Climate change leads to adverse consequences with its various effects on natural and human systems caused by extreme hot and cold weather events and deterioration in air quality, such as diseases, increase in the frequency of food, water, and vector-borne infections and expansion in their regions, malnutrition and skin diseases, and conditions affecting mental health (5). The number of societies whose health conditions deteriorate as a result of exposure to such adverse consequences is increasing (3).

Although climate change has global impacts, it delivers different outcomes in different societies regarding regional epidemiological and socioeconomic characteristics. The communities that contribute the least to climate change and are the most vulnerable are more affected by climate change (3). Ethnic minorities, those with chronic diseases, those with disabilities, women, pregnant women, children, the elderly, immigrants, communities facing housing and food insecurity, and those with limited access to health systems are at higher risk (6).

Human-caused climate change affects many weather and climate regions around the world. Climate action not only ensures a healthy environment, but also includes effects such as reducing air pollution, increasing physical activity by active transportation, and healthy nutrition. This review, "Impacts of Climate Change on Health: A Current Assessment" has been conducted to provide evidence and guide the scientific research aiming to protect individuals, communities, cities, regions, countries, and the world from the health impacts of climate change, and to prepare for, adapt to, and gain resilience to the health impacts of climate change.

2. MATERIAL AND METHODS

As the first step of the study, in the literature review phase, 60 of the accessed literature was included in the review within the scope of the study. In the scientific literature, emphasis has been placed on publications examining the different health effects that climate change may cause on human health. The data obtained within this scope was searched on databases between June and July 2024 and was eliminated and synthesized according to the current literature. Articles that may be relevant to the subject were accessed in electronic databases. Through Elsevier, Cochrane, Pubmed, Scopus, YÖKTEZ, and DergiPark databases, local and foreign theses, reports of national and international studies, articles, and gray literature were evaluated.

In the second step of the study, keyword searches were conducted for the main headings in the determined databases. Kiraz's Climate Change Education Modules Series, Module 14 was used to determine the keywords (7). The subject was examined under 6 main headings: 'the effects of extreme hot and cold weather events on health', 'the effects of ultraviolet radiation', 'the effects of changes in air quality', 'the effects of food and water-related health problems', 'health problems associated with vectors' and 'mental problems'.

In the third stage of the study, the abstracts of the studies collected were examined by the author. Publications that included policies implemented by countries on climate change and health, studies examining knowledge-awareness-attitude, and public health practices were not included in the review. In order to avoid duplication in different databases in the reviewed articles, publications were filtered. As a result of the literature review, 60 publications published between the years 2000-2024 were decided to be included in the study.

3. RESULTS AND DISCUSSION

When the studies were examined according to their publication date, it was observed that the oldest study was from 2005 and included studies conducted up to the present day. There were also older studies that were not included in the review in order to keep the subject up-to-date. The publication dates of the 42 studies included in the review are listed in Table 1, arranged from the oldest to the newest.

Table 1. Studies used as sources in the literature review on the Effects of Climate Change on Human Health

NO	Name	Leader Writer	Year	Journal/Report	Health Effects
1	Environmental temperature and mortality	Näyhä S	2005	International Journal of Circumpolar Health	Effects of Extreme Hot-Cold Weather Events
2	Solastalgia: The distress caused by environmental change	Albrecht, G	2007	Australasian Psychiatry	Mental Problems
3	Environmental temperature and mortality	Mourtzoukou, EG	2007	International Journal of Circumpolar Health	Effects of Extreme Hot-Cold Weather Events
4	Correlation of <i>Borrelia burgdorferi</i> sensu lato prevalence in questing <i>Ixodes ricinus</i> ticks with specific abiotic traits in the western Palearctic	Estrada-Peña, A	2011	Applied and environmental microbiology	Vector-Related
5	Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s	World Health Organization	2014	World Health Organization	Impacts of Food and Water-Borne Health Problems
6	Examining the Association Between Apparent Temperature and Mental Health-Related Emergency Room Visits in California	Basu R	2018	American Journal of Epidemiology	Effects of Extreme Hot-Cold Weather Events
7	Changes in extreme events and the potential impacts on human health	Bell, J. E	2018	Journal of the Air & Waste Management Association	Impacts of Food and Water-Borne Health Problems
8	Vector-borne diseases and climate change: a European perspective	Semenza, J. C	2018	FEMS microbiology letters	Vector-Related
9	Impact of anthropogenic CO ₂ emissions on global human nutrition	Smith, M. R	2018	Nature Climate Change	Impacts of Food and Water-Borne Health Problems
10	COP24 special report: health and climate change	World Health Organization	2018	World Health Organization	General Health Effects
11	Temperature and mental health: Evidence from the spectrum of mental health outcomes	Mullins JT	2019	Journal of Health Economics	Effects of Extreme Hot-Cold Weather Events
12	Climate Change Impacts on Human	Urbanization and Climate Change of	2019	Climate Change Training Module	General Health Effects

	Health	the Republic of Turkey		Series 14	
13	Climate Futures and Projected Mortality Due To Non-Optimal Temperature From 2020 To 2100: A Global Burden of Disease Forecasting Study	Burkart, K. G	2020	The Lancet	Mental Problems
14	Climate change: Unpacking the burden on food safety. Food safety and quality series No. 8	Food and Agriculture Organization	2020	Food and Agriculture Organization	Impacts of Food and Water-Borne Health Problems
15	Are there differences in immune responses following delivery of vaccines through acutely or chronically sun-exposed compared with sun-unexposed skin?	Hart, P. H	2020	Immunology Volume 159 Issue 2	Effects of UV radiation
16	Ultraviolet radiation exposure and the risk of herpes zoster in three prospective cohort studies.	Kawai, K	2020	In Mayo Clinic Proceedings	Effects of UV radiation
17	Burden of cause-specific mortality attributable to heat and cold: A multicity time-series study in Jiangsu Province, China	Ma Y	2020	Environment International	Effects of Extreme Hot-Cold Weather Events
18	Solar ultraviolet radiation and vitamin D deficiency on Epstein-Barr virus reactivation: observational and genetic evidence from a nasopharyngeal carcinoma-endemic population.	Mai, Z	2020	In Open Forum Infectious Diseases US: Oxford University Press	Effects of UV radiation
19	Effects Of Climate Change On Health	Olgun, E	2020	Voice of Nature	General Health Effects - Changes in Air Quality
20	Effects of solar radiation and an update on photoprotection	Saucedo, G. M. G	2020	Anales de Pediatría (English Edition)	Effects of UV radiation
21	Ultraviolet radiation and chronic inflammation—Molecules and mechanisms involved in skin carcinogenesis: A narrative review.	Ciążyńska, M	2021	Life	Effects of UV radiation

22	UV Index does not predict ocular ultraviolet exposure	Hatsusaka, N	2021	Translational Vision Science & Technology	Effects of UV radiation
23	Climate anxiety in children and young people and their beliefs about government responses to climate change: a global survey	Hickman, C	2021	The Lancet Planetary Health	Mental Problems
24	Is there an association between hot weather and poor mental health outcomes? A systematic review and meta-analysis.	Liu J	2021	Environment International	Effects of Extreme Hot-Cold Weather Events
25	Climate impacts associated with reduced diet diversity in children across nineteen countries	Niles, M. T	2021	Environmental Research Letters	Impacts of Food and Water-Borne Health Problems
26	Impacts of Climate Change on Human Health and Adaptation of Health System to Climate Change: International Classification of Diseases (ICD)	Özmen, A	2021	Aydın Adnan Menderes University Master Thesis	General Health Effects-Changes in Air Quality
27	Climate change impacts on vector-borne diseases in Europe: Risks, predictions and actions.	Paz, S	2021	The Lancet Regional Health–Europe	Vector-Related
28	Weather and Climate Extreme Events in a Changing Climate. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change	Seneviratne, S. I	2021	Cambridge University Press	Effects of Extreme Hot-Cold Weather Events
29	Environmental effects of stratospheric ozone depletion, UV radiation, and interactions with climate change: UNEP Environmental Effects Assessment Panel, Update 2021	Barnes, P. W	2022	Photochemical & Photobiological Sciences	Effects of UV radiation
30	2022: Food, Fibre,	Bezner Kerr	2022	Cambridge	Impacts of Food

	and Other Ecosystem Products. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change			University Press	and Water-Borne Health Problems
31	Effects of solar radiation on the eyes	Chawda, D	2022	Cureus	Effects of UV radiation
32	2022: Health, Wellbeing, and the Changing Structure of Communities. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change	Cissé, G., R	2022	Cambridge University Press	Impacts of Food and Water-Borne Health Problems
33	Thinking about the future of food safety – A foresight report	Food and Agriculture Organization	2022	Food and Agriculture Organization	Impacts of Food and Water-Borne Health Problems
34	Technical series on adapting to climate sensitive health impacts: diarrhoeal diseases	World Health Organization	2022	World Health Organization	Impacts of Food and Water-Borne Health Problems
35	Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change	Intergovernmental Panel on Climate Change	2022	Cambridge University Press	Impacts of Food and Water-Borne Health Problems
36	Climate change and its implications for food safety and spoilage	Misiou, O	2022	Trends in Food Science & Technology	Impacts of Food and Water-Borne Health Problems
37	The 2023 report of the Lancet Countdown on health and climate change: Health at the mercy of fossil fuels	Romanello, M	2023	The Lancet	General Health Effects

38	Climate change and health: three grand challenges	Campbell-Lendrum, D	2023	Nature Medicine	General Health Effects – Mental Problems
39	Childhood sunburn and risk of melanoma and non-melanoma skin cancer: a Mendelian randomization study	Li, Y	2023	Environmental Science and Pollution Research	Effects of UV radiation
40	Levels and trends in child malnutrition: UNICEF/WHO/world bank group joint child malnutrition estimates: key findings of the 2023 edition	World Health Organization	2023	World Health Organization	Impacts of Food and Water-Borne Health Problems
41	Mental health impacts of climate change among vulnerable populations globally: an integrative review	White, B. P	2023	Annals of global health	Mental Problems
42	Effects of Climate Change on Health	Republic of Turkey Ministry of Health	2023/2024	General Directorate of Public Health Report	General Health Effects - Changes in Air Quality - Vector-Related

Climate change endangers human health and life in every region of the world (1). Climate change has effects on a global scale with causes such as extreme hot-cold weather events, droughts and floods, changes in air quality, with increased frequency and spread of food, water, and vector-borne diseases and mental health problems (2). Low-income communities, immigrants, the elderly, children, pregnant women, and those with mental health problems are affected more and in different ways by climate change (3).

3.1 Effects of Extreme Hot-Cold Weather Events on Health

One of the important weather events caused by climate change is the excessive increase in air temperature. Similarly, the accelerated change process in climate also leads to an increase in cold weather events in some climate regions (8). It is advocated that increased temperature accelerates blood circulation, increases sweating and dehydration, creates a tendency for coagulation, and increases cholesterol levels and all these changes increase cardiovascular mortality (9). On the other hand, the increase in cold weather events leads to suppression of the immune system, vasoconstriction in the respiratory system, and an increase in respiratory tract infections and related deaths (10).

Abnormal changes in air temperature affect the functioning of signaling molecules, especially neurotransmitters, that play a role in many biological pathways. High temperatures also cause changes in serotonin and dopamine levels and the balance of these molecules, which leads to deterioration in mood, cognitive functions, and many functional skills (11). With the heat waves that last for several days, mental excitability increases, and tension, aggressive mood, and suicidal tendencies can be seen (12).

Studies have reported that heat waves affect all systems and that a 1°C increase in air temperature increases mental health-related mortality by 2.2% and morbidity by 0.9%. Especially in the elderly population, the extreme heat and cold air effects are much more prominent, and children, pregnant women, immobile care patients, mentally retarded groups, and those living in low-middle income countries are at greater risk. Occupational features are also important, and especially outdoor workers and athletes have been defined as more at risk than other groups (13,14).

3.2 Effects of Ultraviolet Radiation on Health

Ultraviolet radiation (UVR) comes naturally from the sun, but can also be generated by artificial sources used in industry, commerce, and recreation. Global warming and climate change resulting from human-induced pollution and increased industrialization activities cause depletion of the stratospheric ozone layer, increasing the amount of UVA and UVB reaching the earth's surface. This case affects human health, animals, marine organisms, and plant life (15,16).

The effects of UVR on health vary depending on the time spent under the sun, the work and physical activities performed, the area of skin surface exposed, and the implementation of sun protection behaviors. Children, the elderly, workers working outdoors and in open areas, and athletes involved in outdoor activities are at greater risk from the harmful effects of UVR than people working/living indoors (15).

In humans, increased UVR exposure has acute and chronic adverse effects on the skin, eyes, and immune system (17). Sunburn (skin redness, edema, and blistering) and photodermatoses (sun allergy, dermal drug reactions) are acute inflammatory skin reactions resulting from increased skin UVR exposure (17-20). Chronic excessive UVR exposure is the main environmental risk factor that causes photoaging, melanoma, and nonmelanoma skin cancers through DNA damage and somatic mutations, inflammation, oxidative stress, and suppression of the immune response (21). Photokeratitis and photoconjunctivitis are among the acute effects of UVR exposure on the eye (17). Chronic exposure is associated with an increased risk of lens cataracts, pterygium, pinguecula, macular degeneration, squamous cell carcinoma of the cornea and/or conjunctiva, and intraocular melanoma (22,23). Besides, some oral and topical medications such as antibiotics, oral contraceptives, benzoyl peroxide products, and some cosmetics can increase skin and eye sensitivity to UVR in all skin types (16). UVR exposure can cause acute skin and eye reactions in those using such medications. It has been reported that increased UVR exposure may increase the risk of viral, bacterial, parasitic, or fungal infections in humans due to changes in the activity and distribution of some cells responsible for immune reactions and is related to a decrease in T cell-related immune response (17). This has been associated with a decrease in vaccine responses where cellular immunity is at the forefront, and it has been reported that high UVR levels can reduce the effectiveness of vaccines, especially in developing countries (17,24). Additionally, studies are reporting that intense UVR exposure can cause reactivation of latent Herpes Simplex Virus 1 (HSV 1), Epstein Bar Virus (EBV), and Varicella Zoster Virus (VZV) (34,35).

3.3 Effects of Changes in Air Quality on Health

As a result of human activities, carbon emissions and the amount of particulate matter increase, and sun rays are inadequately reflected and are trapped in the atmosphere, causing more warming by creating a natural greenhouse effect (27). Both indoor and outdoor air pollution cause a health risk. The causes of indoor air pollution are cigarette smoke and smoke from solid fuels. Particulate matter (PM), carbon monoxide, ozone, nitrogen dioxide, and sulfur dioxide can be given as examples of outdoor pollutants (28). Up to 99% of the world's population lives in areas where air pollution levels exceed WHO guideline limits (29).

In some regions, variabilities in temperature and rain can cause an increase in both the frequency and the extent of forest fires. Morbidity and mortality are affected by the spread of toxic gases and particles into the atmosphere. This condition particularly affects vulnerable groups such as children and the elderly (30).

The World Health Organization (WHO) estimates that exposure to fine particles causes diseases such as stroke, cardiovascular diseases, chronic obstructive pulmonary diseases and pneumonia and cancer, and that approximately 7 million people die each year due to air pollution (28). In places where air quality is poor, diseases such as upper respiratory tract infections, asthma, bronchitis, allergic rhinitis, and sinusitis are more commonly observed. Both PM and ozone have been stated to be related to allergic respiratory diseases (31).

3.4 Impacts of Food and Water-Borne Health Problems

With climate change, the incidence of climate-related food and water-borne diseases has increased (5). Pathogens such as Salmonella and Campylobacter are more commonly seen with increasing temperatures, and these pathogens become more resistant to antimicrobial agents (32,33). Various climate-sensitive pathogens, including Vibrio spp., have caused regional increases in water- and food-borne diseases (5). Floodwaters can reduce access to safe drinking water by contaminating water supplies and can lead to outbreaks of waterborne diseases such as Cholera (34).

Increasing temperatures, periods of consequent drought and rainfall, acidification of oceans, and rising sea levels all lead to biological and chemical contamination of food (34). Due to the different effects of climate change, the increase

in the amount of heavy metals accumulated in the soil, the contamination of agricultural products with mycotoxins, and the widespread of use of pesticides to meet the increasing global food demand are expected (35). Droughts, on the other hand, lead to consequences such as restricted access to safe water, contamination of water resources, and negative effects on agricultural production (36).

According to WHO, it is estimated that there will be 148.1 million stunted, 45 million underweight, and 37 million obese children under the age of five in the world in 2022 (37). It is known that increasing air temperatures have negative effects on the variety of nutrients accessible to children due to drought and food insecurity (38). Due to the effect of human-induced carbon dioxide emissions, it is expected that the nutritional quality of various agricultural products will decrease and malnutrition will be seen especially in communities that use plants as a source of food (39). Malnutrition and weakened immunity also increase the burden of foodborne diseases (35).

Unless there is sufficient progress in adaptation, climate change is expected to increase the incidence of food and waterborne diseases such as Salmonella and Campylobacter infections, diarrhea caused by these pathogens and malnutrition, and restrict access to healthy foods (40,41).

3.5 Vector-Related Health Problems

Rainfall irregularities and increased air temperatures caused by climate change may create more favorable conditions for both pathogens and vectors such as mosquitoes and ticks (43). Vector-borne diseases are the best-studied group of diseases to evaluate the health impacts of climate change because they can be assessed both over an extensive area and more clearly against variable factors (30). According to WHO, the most lethal vector-borne diseases are malaria, which is estimated to cause 620,000 deaths in 2022, and Dengue fever, which is estimated to cause 40,500 deaths (44). The incidence of Lyme disease has been associated with warm winters, warmer summer temperatures, lower temperature variations, and higher vegetation cover (45). Projections express that tick-borne infections will move to higher latitudes and altitudes despite improved surveillance and the success of vaccination programs (46).

3.6 Mental Problems

Climate change also has a significant impact on mental health. The psychological consequences of climate-related disasters, environmental degradation, and chronic stress associated with climate change are leading to an increase in various mental health problems, including anxiety, depression, post-traumatic stress disorder (PTSD), and eco-anxiety. Extreme weather events such as hurricanes, forest fires, floods, and heat waves have been shown to directly affect mental health by causing trauma, displacement, and loss.

A study conducted on young people in ten countries found that 60% of young people felt very anxious about climate change, and 45% were negatively affected in their daily functions (47). The study emphasized that these feelings of climate anxiety were particularly pronounced among young people in developing countries, where the impacts of climate change were more visible and severe. The term 'solastalgia', which describes the psychological distress caused by environmental change, also came to the fore again during this era. In a study focusing on rural communities in Australia, prolonged droughts and forest fires were associated with increased loss, hopelessness, and solastalgia (48). Research shows that these long-term environmental changes, combined with economic challenges, lead to higher rates of depression and substance abuse disorders in affected communities. Increasing global temperatures and heat waves caused by climate change have been shown to worsen mental health issues, especially in urban areas. There was a 5% increase in suicide rates during heat waves in European cities and a significant increase in hospitalizations among individuals with diagnosed mental illnesses. The study emphasized that high temperatures can disrupt sleep, increase irritability, and worsen symptoms of anxiety and depression (49). The mental health of children and adolescents is particularly affected by climate change, as they are more vulnerable to feelings of helplessness and fear about their future. One study reported that children exposed to climate-related disasters are more likely to experience long-term psychological disorders, including developmental delays and behavioral problems (50).

4. CONCLUSION AND RECOMMENDATIONS

Climate change is one of the most critical global problems of the 21st century, creating environmental, social, and economic multidimensional impacts. Its impacts on human health seem to be much more significant and devastating. However, despite this, studies on its direct and indirect impacts on human health are relatively few. Global temperature increases and extreme weather events due to climate change cause serious and long-term negative impacts such as drought, food shortages, public health problems such as the spread of infectious diseases, a decrease in biodiversity, an

increase in respiratory and cardiovascular diseases, and heat-related deaths. To cope with and adapt to these impacts, it is essential to take urgent and effective precautions at both national and international levels.

Various health impacts of climate change can be reduced with adaptation programs planned by considering realistic scenarios and implemented in a timely manner. Increasing the use of clean energy sources, better planning of waste management, and encouraging society to use green transportation options may play an important role in this aim. It is very important to create public awareness about the effects that extreme air temperature changes may create, especially in attributed risk groups, to manage health resources, and to adapt hospitals and health institutions to this issue.

There is a need for new researchers on climate and health, a common data system, a medical curriculum including the health effects of climate change, and financial resources. The abilities and resources of health professionals to assess, diagnose, treat, record, and inform the public about the effects of climate change on health should be reviewed and increased. Health authorities should undertake and implement various tasks such as predicting the impacts and consequences of climate change on health, finding timely solutions to these, and ensuring that these solutions are sustainable.

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