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Considering the Health Effects of Climate Change: A Scoping Review

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Abstract: The consequences of climate change significantly affect human health. The purpose of this review is to outline the progress of studies in the field of climate and health to date and to shed light on future research. The PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews) checklist was used to guide the study. A literature search was conducted on September 13, 2024, using PubMed and Google Scholar, covering the period from 2019 to 2024. Of the included studies, 65(40.12%) were from Europe, 43(26.54%) from Asia, and 34 (20.98%) from North America. The most commonly used research types included were reviews (%31.48) and modelling studies (%20.37). The most frequently used climate change evidence category in the included studies were “extreme weather events and heat/cold air waves”. The most frequently obtained health effects category in the compiled studies was "diseases related to heat and cold". This review summarizes research conducted in the past five years on the health impacts of climate change, identifying knowledge gaps and research priorities. Future studies should combine quantitative and qualitative methods to better understand the health impacts of climate change, assess health risks, and develop effective interventions.

İklim Değişikliğinin Sağlık Etkilerinin Ele Alınması: Kapsam Derlemesi

Anahtar Kelimeler
İklim değişikliği, Sağlık etkileri, Halk sağlığı, Kapsam derlemesi

Öz: İklim değişikliğinin sonuçları insan sağlığını önemli ölçüde etkilemektedir. Bu derlemenin amacı, iklim ve sağlık alanındaki çalışmaların bugüne kadarki ilerlemesini özetlemek ve gelecekteki araştırmalara ışık tutmaktır. PRISMA-ScR (Sistematik İncelemeler ve Meta-Analizler için Tercih Edilen Raporlama Öğeleri) kontrol listesi çalışmayı yönlendirmek için kullanılmıştır. 13 Eylül 2024 tarihinde, PubMed ve Google Scholar kullanılarak 2019'dan 2024'e kadar olan dönemi kapsayan bir literatür taraması gerçekleştirilmiştir. Derlenen çalışmaların 65'i (%40,12) Avrupa'dan, 43'ü (%26,54) Asya'dan, 34'ü (%20,98) Kuzey Amerika'dandı. Derlenen çalışmalar arasında en sık kullanılan araştırma türleri derleme (%31,48) ve modelleme çalışmaları (%20,37) olmuştur. Derlenen çalışmalarda en sık kullanılan iklim değişikliği kanıt kategorisi “aşırı hava olayları ve sıcak/soğuk hava dalgaları” olmuştur. Derlenen çalışmalarda en sık elde edilen sağlık etkileri kategorisi “sıcak ve soğuğa bağlı hastalıklar” olmuştur. Bu derleme, son beş yılda iklim değişikliğinin sağlık üzerindeki etkilerine dair yapılan araştırmaları özetlemekte ve bilgi boşlukları ile araştırma önceliklerini belirlemektedir. Gelecekteki çalışmalar, iklim değişikliğinin sağlık üzerindeki etkilerini daha iyi anlamak için nicel ve nitel yöntemleri birleştirerek, sağlık risklerini ölçmeli ve etkili müdahaleler geliştirilmelidir.

1. INTRODUCTION

According to the Lancet Countdown 2024: Health and Climate Change Report, Europe faced record-breaking temperatures during the summer of 2023, with extreme heat waves affecting the southern half of the continent, causing temperatures to exceed 45°C in some regions. In Europe, temperatures are rising twice as fast as the global average, posing a threat to public health across the continent. The 2024 report emphasizes the negative impacts of climate change on human health and highlights the delays in climate action by European countries [1].

The World Health Organization (WHO) predicts that between 2030-2050, climate change will lead to approximately 250,000 additional deaths annually due to malaria, malnutrition, heat stress and diarrhea [2,3]. More than half of these additional deaths are expected to occur in Africa by 2050 [4].

At COP 24, for the first time, a special report on health and climate change was published [5]. The COP 24 Special Report on Health and Climate Change identified climate change as the greatest public health issue of the 21st century. COP 28 is a turning point for climate and health. For the first time, "Health Day" was celebrated at this COP, and the "Climate and Health Declaration" was published [6,7].

The Alliance for Action on Climate Change and Health (ATACH) initiative is another significant effort in the field of climate and health. ATACH is introduced as an initiative that takes on the responsibilities of facilitating international change on priority issues, monitoring, quality assurance, coordinating access to financing, information sharing, and technical assistance. It has legal status granted by the WHO, and its secretariat is operated by the WHO [8].

The results of climate change significantly affect human health. The three most common health effects are infectious diseases, mortality and respiratory, cardiovascular or neurological outcomes [9]. However, in studies related to climate change, the impact of climate change on health has remained in the background [10]. In 2010, the WHO, in collaboration with the United Nations Development Programme (UNDP), introduced the first global project for public health adaptation to climate change [11]. Through the Climate Promise Project, carried out by the UNDP, work has been conducted with more than 120 countries and regions to reduce greenhouse gas emissions and cope with the challenges posed by climate change. Türkiye is one of these countries. In Türkiye, the 'İklimin', 'İklimi Duy', 'İklimce Sohbetler' and 'İklime Uyum' Projects have been carried out, becoming pioneers in their fields [12-14].

Efforts are accelerating to reduce and adapt to the impacts of climate change on public health.In the U.S., the Centers for Disease Control and Prevention (CDC) developed and launched the Building Resilience Against Climate Effects (BRACE) framework to support local efforts to adapt to the impacts of climate change [15]. The CDC's work on climate and health began in 2006, the climate and health program was launched in 2009, and Türkiye's climate and health strategy efforts started in 2010. In 2015, Türkiye published the Strategy and Action Plan on the Adverse Effects of Climate Change on Human Health, which is the main outcome of the work carried out by the Republic of Türkiye Ministry of Health in collaboration with the World Health Organization [16].

In 2022, Türkiye's Health and Climate Change Profile was published on the World Health Organization's website, highlighting Türkiye's opportunities, strengths, weaknesses, and expected future threats in the face of climate change. Türkiye's 2024-2030 Climate Change Mitigation and Adaptation Strategy and Action Plans have been prepared. The impacts of climate change on public health and ways to combat them have been included in these national reports [17].

The 'Climate and Health Journal,' specifically targeting the study of climate and health research, was first published in 2021, followed by 'The Journal of Climate Change and Health,' which began publication in the same year [18,19].

The field of climate change is increasingly attracting the attention of researchers. As mentioned above in Turkiye there is a noticeable effort to hold awareness through the academic community by researchers. However, studies related to the health effects of climate change remain limited. The weak evidence base in the field of climate and health affects the development of health-centered international and national policies. The purpose of this review is by outlining the progress of studies in the field of climate and health to date to identify existing knowledge gaps regarding the relationship between climate change and health. Thus, it is aimed to provide comprehensive guidance for future research, from topic selection to methodological approaches, and to encourage an increase in studies addressing the effects of climate change on health.

2. MATERIAL AND METHOD

2.1. Protocol

We utilized the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist to direct our research [20]. Our process was informed by Arksey and O'Malley's five-stage framework [21]. These stages include formulating research questions, identifying relevant studies, selecting studies, synthesizing and interpreting essential information (referred to as "charting the data"), and compiling, summarizing, and presenting the findings.

2.2. Search Criteria

A literature search was conducted using PubMed and Google Scholar on September 13, 2024, covering the period from 2019 to 2024.

The subsequent keywords and their combinations were employed for the literature search on PubMed: (climate change[Title/Abstract]) AND ((health impact[Title/Abstract]) OR (diseases related to heat[Title/Abstract]) OR (diseases related to cold[Title/Abstract]) OR (side effects of ultraviolet radiation[Title/Abstract]) OR (health problems caused by changes in air quality[Title/Abstract]) OR (diseases related to food[Title/Abstract]) OR (diseases related to water[Title/Abstract]) OR (changing infectious disease agents[Title/Abstract]) OR (vector related diseases[Title/Abstract]) OR (mental health issues[Title/Abstract]) OR ("re-emerging diseases"[Title/Abstract]) OR (new diseases[Title/Abstract]))

The same words or sequences of words were searched in Turkish in Google Scholar in Turkish. Since some words or sequences of words can have similar meanings in Turkish but with different spellings, more words were included in the search than in English. The English and Turkish keywords we searched for are shown in Table 1.

Table 1. The keywords in English and Turkish.

	English Keywords		Turkish Keywords
1.	Climate change	1.	İklim değişikliği
2.	Health impact	2.	Sağlık etkisi
3.	Diseases related to heat	3.	Sıcağa bağlı hastalıklar, sıcak ile ilişkili hastalıklar, sıcakla ilişkili hastalıklar
4.	Diseases related to cold	4.	Soğuğa bağlı hastalıklar, soğuk ile ilişkili hastalıklar, soğukla ilişkili hastalıklar
5.	Side effects of ultraviolet radiation	5.	Ultraviyole radyasyonun yan etkileri, uv radyasyonun yan etkileri
6.	Health problems caused by changes in air quality	6.	Hava kalitesindeki değişikliklerin neden olduğu sağlık sorunları, hava kalitesindeki değişikliklerin neden olduğu sağlık problemleri, hava kalitesindeki değişikliklerin neden olduğu hastalıklar, hava kalitesinin bozulmasına bağlı sağlık sorunları, hava kalitesinin bozulmasına bağlı sağlık problemleri, hava kalitesinin bozulmasına bağlı hastalıklar, hava kalitesinin bozulması ile ilişkili sağlık sorunları, hava kalitesinin bozulması ile ilişkili sağlık problemleri, hava kalitesinin bozulması ile ilişkili hastalıklar
7.	Diseases related to food	7.	Gıda ile ilgili hastalıklar, gıdayla ilgili hastalıklar, gıda ile ilişkili hastalıklar, gıdayla ilişkili hastalıklar
8.	Diseases related to water	8.	Suyla ilgili hastalıklar, su ile ilgili hastalıklar, su ile ilişkili hastalıklar, suyla ilişkili hastalıklar
9.	Changing infectious disease agents	9.	Değişen bulaşıcı hastalık etkenleri
10.	Vector related diseases	10.	Vektörlerle ilgili hastalıklar, vektörlerle ilişkili hastalıklar
11.	Mental health issues	11.	Ruhsal sorunlar, ruhsal sağlık sorunları, mental sağlık sorunları, mental sorunlar
12.	Re-emerging diseases	12.	Yeniden ortaya çıkan hastalıklar
13.	New diseases	13.	Yeni hastalıklar

The keywords and combinations listed below were utilized for the literature search on Google Scholar in Turkish: “iklim değişikliği” AND “sağlık etkisi” OR “sıcağa bağlı hastalıklar” OR “sıcak ile ilişkili hastalıklar” OR “sıcakla ilişkili hastalıklar” OR “soğuğa bağlı hastalıklar” OR “soğuk ile ilişkili hastalıklar” OR “soğukla ilişkili hastalıklar” OR “ultraviyole radyasyonun yan etkileri” OR “UV radyasyonun yan etkileri” OR “hava kalitesindeki değişikliklerin neden olduğu sağlık sorunları” OR “OR “hava kalitesindeki değişikliklerin neden olduğu sağlık problemleri” OR “hava kalitesindeki değişikliklerin neden olduğu hastalıklar” OR “hava kalitesinin bozulmasına bağlı sağlık sorunları” OR “hava kalitesinin bozulmasına bağlı sağlık problemleri” OR “hava kalitesinin bozulmasına bağlı hastalıklar” OR “hava kalitesinin bozulması ile ilişkili sağlık sorunları” OR “hava kalitesinin bozulması ile ilişkili sağlık problemleri” OR “hava kalitesinin bozulması ile ilişkili hastalıklar” OR “gıda ile ilgili hastalıklar” OR “gıdayla ilgili hastalıklar” OR “gıda ile ilişkili hastalıklar” OR “gıdayla ilişkili hastalıklar” OR “suyla ilgili hastalıklar” OR” su ile ilgili hastalıklar” OR “su ile ilişkili hastalıklar” OR “suyla ilişkili hastalıklar” OR “değişen bulaşıcı hastalık etkenleri” OR “vektörlerle ilgili hastalıklar” OR “vektörlerle ilişkili hastalıklar” OR “ruhsal sorunlar” OR “ruhsal sağlık sorunları” OR “mental sağlık sorunları” OR “mental sorunlar” OR “yeniden ortaya çıkan hastalıklar” OR “yeni hastalıklar”

2.3. Selection Criteria and Screening

Publications written in English or Turkish from the last five years (2019-2024) were included in the review. No restrictions were placed on the type of research or publication.

During the initial selection phase, the abstract of each study was reviewed and assessed. Papers that did not meet the following criteria were excluded from our review:

- Studies that do not examine the effects of climate change on human health.
- Studies not published in English or Turkish.
- Studies for which the full text is not available.

2.4. Data Extraction

The selected studies were analyzed and recorded for the following details: first author, publication date, journal name, type of research, location (country and continent),

climate signal examined, primary health effects associated with the climate signal, and any limitations of the study.

2.5. Data Analysis

In the full texts of the studies, qualitative analysis was conducted using the MaxQDA program, and the results were visualized with tables and a word cloud. The data extracted from the studies and transferred to an Excel table were analyzed using mixed methods with the MaxQDA program. Graphs were created using Excel.

3. RESULTS

The detailed results of the study selection are presented in Figure 1.

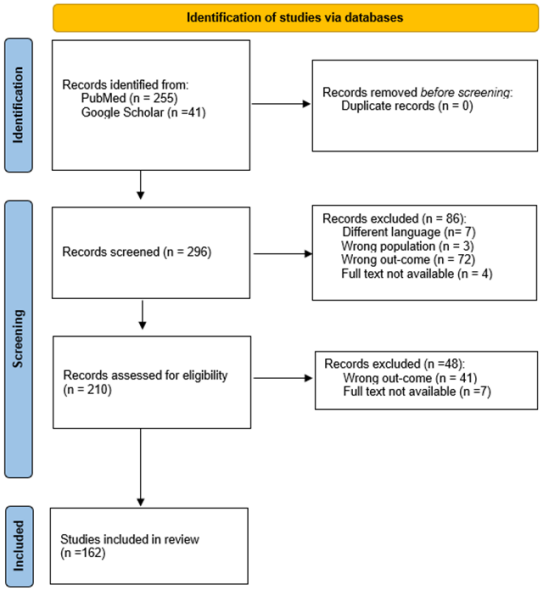

Figure 1. The selection process of the studies included in the Scoping Review-2024 according to the PRISMA-ScR flowchart [22]

A total of 296 studies were identified through a literature search, with 255 from PubMed and 41 from Google Scholar. Based on the inclusion and exclusion criteria, 7 studies were excluded due to being in a different language, 3 were excluded because they involved the wrong population, and 72 were excluded for reporting irrelevant outcomes. As a result, 210 full-text articles were assessed. A total of 189 English studies and 21 Turkish studies were evaluated according to the inclusion and exclusion criteria. Five English studies were excluded because their full text was not accessible, and 34 studies were excluded for not being related to the health impacts of climate change. Similarly, two Turkish studies were excluded due to inaccessible full texts, and 7 were excluded for not being related to the health impacts of climate change. In total, 162 studies were included in the scoping review, consisting of 150 English studies and 12 Turkish studies.

The distribution of studies included in the Scoping Review by 2024 is presented in Figure 2. The distribution of the included studies by country is shown on a world map in Figure 3. The highest number of studies was conducted in 2021, within the 2019-2024 range. Of the included studies, 65 (40.12%) were from Europe, 43 (26.54%) from Asia, 34 (20.98%) from North America, and the remaining studies were conducted by authors from Africa, Oceania, and South America.

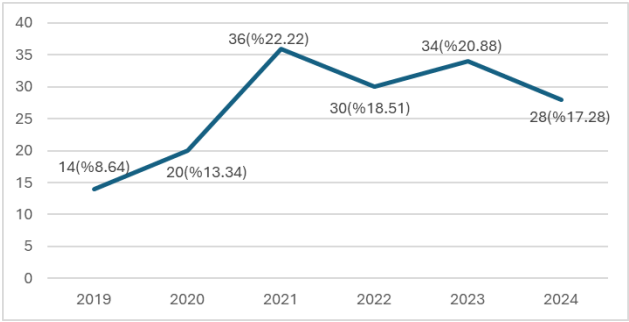

Figure 2. The distribution of the studies included in the Scoping Review-2024 by year

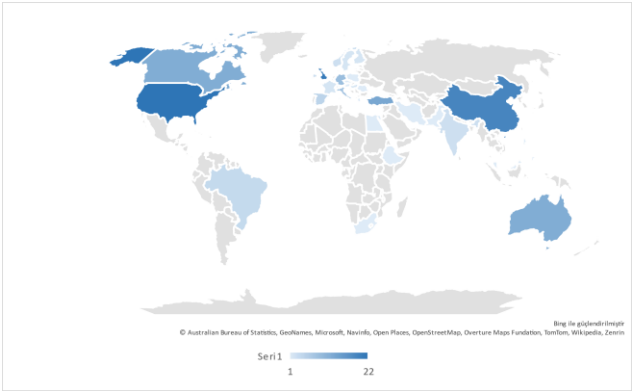

Figure 3. The distribution of the studies included in the Scoping Review-2024 by country

The most commonly used research types among the included studies were reviews (%31.48) and modelling studies (%20.37). The climate change evidences, and health impacts were categorized [23]. These categories are presented in Table 2.

Table 2. The climate change evidences, and the health impacts are categorized [23]

Climate Change Evidences	Health Impacts
Extreme weather events	Diseases related to heat and cold
Changes in water resources	Side effects of ultraviolet radiation
Heat/cold air waves	Health issues caused by air pollution
Rising sea levels	Food and waterborne diseases
Changes in air quality	Changing infectious disease agents
Increase in ultraviolet radiation	Vector-borne diseases
	Mental health issues
	Emerging and re-emerging diseases

The climate change evidences in the included studies were categorized as extreme weather events, changes in water resources, heat/cold air waves, rising sea levels, changes in air quality, increase in ultraviolet radiation and general climate change. These categories are presented in Table 3. The most frequently used climate change evidences category in the included studies were “extreme weather events and heat/cold air waves”.

Table 3. The distribution of the studies included in the Scoping Review-2024 by climate change evidences

Climate Change Evidences	Frequency	Percent (%)
Extreme weather events	66	29.86
Changes in water resources	2	0.90
Heat/cold air waves	65	29.41
Rising sea levels	9	4.07
Changes in air quality	47	21.26
Increase in ultraviolet radiation	2	0.90
General climate change	30	13.57
Total	221	100.00

The health impacts obtained from the included studies were classified as diseases related to heat/cold, side effects of ultraviolet radiation, health issues caused by air pollution, food and waterborne diseases, changing infectious disease agents, vector-borne diseases, mental health issues, emerging and re-emerging diseases. These categories are presented in Table 4. The most frequently obtained health effects category in the compiled studies was "diseases related to heat and cold".

Table 4. The distribution of the studies included in the Scoping Review-2024 by health impacts

Health Impacts	Frequency	Percent
Diseases related to heat and cold	70	24.39
Side effects of ultraviolet radiation	2	0.69
Health issues caused by air pollution	58	20.20
Food and waterborne diseases	38	13.24
Changing infectious disease agents	25	8.71
Vector-borne diseases	33	11.49
Mental health issues	51	17.77
Emerging and re-emerging diseases	10	3.48
Total	287	100.00

The word analysis conducted on the full texts of the included studies shows that the 30 most frequently used words are presented in a word cloud in **Figure 4.**

Figure 4: The 30 most frequently used words in the studies included in the Scoping Review-2024

4. DISCUSSION AND CONCLUSION

This scoping review summarizes research published between 2019 and 2024 on the health impacts of climate change and evaluates the findings in light of the current literature. Most of the 162 studies included in this review originate from Europe, North America, and Asia. This indicates a growing recognition among researchers of the link between climate change and public health. Similarly, the Lancet Countdown 2024 report emphasizes that temperatures in Europe are rising twice as fast as the global average, highlighting significant public health risks across the continent [1]. The IPCC Sixth Assessment Report also details the multidimensional health effects of climate change (IPCC, 2023) [24].

In this review, extreme weather events and heat/cold waves were the most frequently cited evidence of climate change. This finding aligns with previous studies showing that heatwaves are associated with increased cardiovascular and respiratory diseases and higher mortality rates [25]. The Lancet Countdown and WHO reports also highlight that heatwaves pose serious risks, especially for the elderly, children, and those with chronic illnesses [26]. Similarly, cold spells have been shown to increase acute health problems and mortality risk [27].

Degradation of air quality emerged as another significant category in this review. Climate change increases levels of pollutants such as ozone and particulate matter, which in turn raise the incidence of asthma, COPD, and other respiratory diseases [26]. Furthermore, Koder et al. (2023) suggest that air pollution caused by climate change could be linked to an additional 250,000 deaths per year between 2030 and 2050 [2]. These findings are in full agreement with current literature.

Vector-borne diseases and food- and water-borne infections also appeared as significant health impacts in this review. As indicated in the IPCC (2023) report, climate change alters the geographic distribution of vectors such as mosquitoes and ticks, increasing the spread of diseases like malaria, dengue, and Lyme disease [24]. In tropical and subtropical regions, rising temperature and humidity increase the prevalence of vector-borne diseases [28]. Additionally, the incidence of water- and food-borne diseases is also rising with climate change [29].

Mental health effects are a topic that has been increasingly emphasized in recent literature and also emerged as a significant category in this review. Increased stress, anxiety, and depression due to climate-related disasters, displacement, and loss of livelihoods have been frequently reported in recent studies (Koder et al., 2023) [2]. Berry et al. (2010) state that the mental health impacts of climate change can have serious consequences at the community level [30]. Therefore, it is essential to integrate mental health services into climate adaptation strategies.

The findings of this review also point to some important gaps in the literature. Notably, there is a lack of studies on the health impacts of climate change in low- and middle-income countries, despite higher exposure and more fragile health systems in these regions [24]. There is also limited research on the long-term health consequences of ecosystem changes [31].

The results support the need for health-focused climate policies, as emphasized in the WHO 2024 report [26].

Health systems should be strengthened to manage the disease burden associated with climate change, early warning systems should be expanded, and health infrastructure should be made more resilient The health sector should also play an active role in combating climate change, supporting the transition to clean energy, reducing greenhouse gas emissions, and promoting sustainable agriculture [31].

This review provides a comprehensive overview of scientific research conducted over the past five years investigating the impacts of climate change on human health, identifying knowledge gaps and potential research priorities in this field. While research on climate change is rapidly expanding, studies on the health effects of climate change remain limited, leaving significant knowledge gaps. Existing research predominantly relies on reviews and modeling studies with limited empirical evidence. The current literature primarily focuses on infectious diseases as health outcomes, including vector-borne diseases, waterborne and foodborne illnesses, zoonotic infections, and emerging infectious diseases. However, the effects of climate change on other health areas remain understudied. Specifically for Türkiye, the number of scientific studies on how climate change impacts health is significantly lower compared to the global research volume.

Future research should use quantitative and qualitative methods together to more accurately assess the impacts of climate change on various health outcomes and develop evidence-based response strategies to mitigate these consequences. Measuring the health risks associated with climate change together with climate signals, their hazards, their effects, and vulnerability analyses will enable us to better understand the geographical distribution, temporal trends and effects of these risks on different demographic groups. This will facilitate the development of targeted and effective interventions to mitigate the health effects of climate change.

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