Review

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Health Consequences of Climate Change: A Systematic Review of Morbidity and Mortality Trends

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Review

Health Consequences of Climate Change: A Systematic Review of Morbidity and Mortality Trends

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Abstract

Background: In recent decades, climate change has increasingly concerned the scientific community not only due to its environmental impact but also due to its direct and indirect impact to human health. The aim of this systematic review was to investigate the current evidence on the impacts of several climate parameters -such as temperature, floods, humidity, air pollution, wildfires and dust- on human health in terms of both mortality and morbidity. Methods: Systematic search for observational studies on climate change effect on human mortality and morbidity published in the last ten years in PubMed, EBSCOhost and Scopus. Results: A total of 57 articles were included in this systematic review. A positive association between extreme heat/cold events, temperature variation and air pollution with mortality was reported from most studies. Moreover, floods might be associated with infant mortality. Cardiovascular diseases are attributed to extreme temperature conditions and humidity is linked to cardiovascular diseases. The chronic exposure to air pollution is strongly associated with respiratory diseases. Floods and wildfires cause mainly respiratory and gastrointestinal illnesses, while dust exacerbates respiratory diseases like asthma. Conclusions: The data derived from the studies confirm the significant impact of temperature, air pollution, humidity, floods, wildfires and dust on both physical and mental health.

Keywords: climate change; human heath; morbidity; mortality; systematic review

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1. Introduction

In recent years, growing concerns about climate change have prompted the scientific community and the World Health Organization (WHO) to investigate its effects not only on the natural environment, but also on human health. In recent decades, many extreme weather phenomena have been observed, such as extreme cold, wildfires, droughts, floods, forest fires, and heatwaves, which are considered the most frequent. [1,2] These extreme phenomena can significantly affect human health, causing several illnesses, and sometimes even death. Moreover, the continuous increase in global temperature, which is expected to gradually exceed 1.5 ∘C in the coming decades, as well as the air pollution contributes to a rise in environment-related diseases and deaths. [3] Wildfires is a globally significant phenomenon affecting both human and wildland ecosystems. [4] The frequency and intensity of fires have increased in recent decades, especially in the United States despite suppression efforts. [5]

Several studies have proved that cardiovascular and cardiometabolic diseases, such as arterial hypertension, arrhythmia, and myocarditis are associated with exposure to air pollution and heatwave. [3,6,7] Especially, the exposure in long lasting heatwaves can cause many diseases, such

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as stroke and coronary heart disease, while low temperatures can also have a critical risk for cardiovascular diseases (CVDs). [8,9]

Regarding the respiratory diseases, including asthma, pulmonary hypertension, acute respiratory infections and chronic obstructive pulmonary disease (COPD), air pollution plays a key role on the development or worsening of the disease. [7] It has been characterized as the most common cause of morbidity and mortality in the world. [10] Moreover, many studies have examined the association between heatwaves (HWs) and respiratory morbidity, presenting, for example that the percentage of chronic bronchitis hospitalization is higher in heatwave conditions. [11,12] Additionally, asthma, the most common chronic respiratory illness, can be worsened by exposure to wildfire smoke, while asthma hospitalization is associated also with low temperatures, as proven by several studies. [13,14] In recent years, Desert Dust Storms (DDS) that contain microbial agents, such as viruses, fungi and bacteria, which are pollutants for asthma and chronic obstructive pulmonary patients, are observed frequently, particularly in Africa and Asia. [15]

Additionally, there are other climate change-related diseases and symptoms, beyond cardiovascular and respiratory diseases. Several symptoms, such as heat syncope hyperthermia, heat rash, heat exhaustion, heatstroke, and heat cramps can occur after a prolonged exposure to a hot environment. [2] Moreover, symptoms such as diarrhea, have been proved that are also related to climate change as some factors like high temperature, contribute to the increase of bacterial pathogens. [16] Besides somatic symptoms and disease such as heat stroke (HS), skin rash, heat syncope, heat fatigue, heat stress, muscle cramps, the climate crisis has also led to mental health symptoms such as decrease in consciousness, perceptual strain and productivity at work. [17] Another finding, which has recently attracted the interest of the public health scientific community, is that the hearing loss, widespread in all regions and countries of the world, is also related to environmental factors, except genetic ones. [18]

As aforementioned, the climate crisis can lead, in some cases, in ill health even death. Several studies have examined the relationship between heatwaves and mortality as the elevated temperature can cause dehydration and hyperthermia and potentially death, especially in the elderly population. [19,20] Globally, it has been observed that mortality increases during the HW periods. [21,22] It is worth mentioned that the most vulnerable populations are infants, children, elderly, as well as individuals with obesity and chronic pathologies. [23]

This study systematically examines how climate factors—such as temperature, floods, humidity, air pollution, wildfires, and dust—affect human health, with a focus on mortality, morbidity, and global vulnerability patterns. It also aims to highlight underrepresented impacts, such as dust storms, hearing loss, and reproductive health.

2. Materials and Methods

2.1. Search Strategy

A systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A computer-based search in three different principal databases such as PubMed, Scopus and EBSCOhost was performed. Peer-reviewed articles were searched in December 2024 based on the following keywords: (Climate change) OR (Global warming) OR (Extreme heat) OR (Extreme cold) OR (Heat waves) OR (Wildfires) OR (Forest Fires) OR (Droughts) AND (effects) AND (mortality OR morbidity).

2.2. Screening Criteria

Two authors of the present study carried out the study selection procedure independently of each other. Uncertainties were discussed after each step among all authors until a solution could be found. Studies had to meet the following inclusion criteria:

1. Types of studies: Observational studies written in English which were published in peer-reviewed journals.

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2. Publication period: between January 1, 2015, to December 31, 2024.
3. Types of exposures: Studies on the health effects of extreme weather events, such as extreme temperature, HWs, cold waves, droughts, dust, floods, storms and wildfires were included.
4. Types of outcomes: Health outcomes including total mortality, cardiovascular mortality and morbidity, respiratory mortality and morbidity, and mental health were considered. Food- and water-borne infectious diseases were also included as they might be highly relevant to direct post-flood mortality and morbidities. [24]

Studies were excluded if they met any of the following criteria:

- Study type: Reviews, letters to the editor, or opinion papers
- Publication date: Published before 2015

The reasoning for the selection of extreme whether events and health outcomes listed above is provided in the discussion section.

2.3. Quality Appraisal of Studies

To ensure methodological rigor, the quality of included studies was assessed using the appropriate Joanna Briggs Institute (JBI) Critical Appraisal Checklists, depending on study design. For observational studies, the checklist consists of eight domains evaluating key elements such as clarity of inclusion criteria, validity and reliability of exposure and outcome measurements, identification and control of confounding factors, and appropriateness of statistical analysis. Each criterion was rated as "Yes," "No," "Unclear," or "Not Applicable." Based on the total number of criteria met and the presence of critical methodological strengths or weaknesses, studies were categorized as high, moderate, or low quality. High-quality studies met most or all relevant criteria with minimal limitations; moderate-quality studies demonstrated some methodological weaknesses, particularly in confounding control or analytical depth; low-quality studies lacked essential methodological clarity or statistical robustness. This structured appraisal process informed the weighting of evidence and strengthened the reliability of the review's conclusions.

3. Results

3.1. Data Management

A total of 57 eligible studies were included in this review. The selection process is illustrated in the flowchart presented in Figure 1. Initially, 920 articles were identified through three databases using the specified keywords. After removing 10 duplicates, the remaining articles were screened based on their titles and abstracts according to the predefined inclusion and exclusion criteria. This process led to the selection of 54 full-text articles deemed relevant to the study aims. Subsequently, a second reviewer independently repeated the selection procedure and identified an additional 3 eligible articles. Thus, a total of 57 studies were ultimately included in the review, as shown in Figure 1.

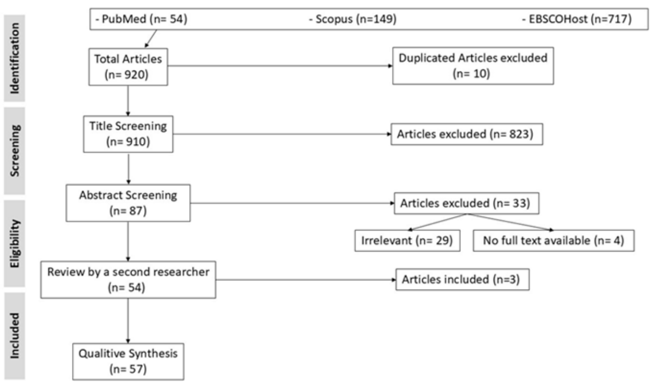

Figure 1. Flowchart for the selection of 57 studies included in this review.

3.2. Quality Appraisal of the Included Studies

All 57 included studies were critically appraised using the Joanna Briggs Institute (JBI) Critical Appraisal Tools appropriate to their design. Based on the number of criteria met, studies were classified into three quality tiers: high, moderate, and low. Specifically, 17 studies (30%) were rated as high quality, having fulfilled at least 7 out of 8 JBI criteria. These studies demonstrated strong methodological rigor, with clearly defined exposure-outcome relationships, robust statistical analyses, and appropriate handling of confounding factors.

The majority of the studies (29 studies; 51%) were rated as moderate quality, meeting 5–6 criteria. While generally sound, these studies presented some limitations, such as limited detail in sample selection, partial adjustment for confounders, or incomplete reporting of outcome measures. Finally, 11 studies (19%) were rated as low quality, often due to methodological weaknesses, such as lack of statistical control, unclear exposure definitions, or insufficient reporting of health outcomes.

Importantly, no studies were excluded based on quality alone. Instead, quality ratings were used to inform the interpretation of findings, giving greater weight to high-quality studies in the synthesis and discussion of results. This stratified approach allowed for a more in-depth insight of the evidence base and helped identify areas where future research should focus on improving methodological robustness.

Table 1 shows the general characteristics of the 57 selected studies including the author, the year of publication, the study population, period and location, the climate factor examined as well as the health outcomes which represent the main findings of the current systematic review.

Table 1. Study characteristics.

Authors & Year of Publication	Study Population	Study Location	Study Period	Climate Parameter	Health Outcome	JBI
Zhou et al., 2022	Stroke deaths	22 towns of East Asian countries	1972-2015	Heat exposure	Heat exposure was significantly associated with high stroke mortality. In total, 287,579 stroke deaths were recorded during the warm season.	Moderate
Achebak et al., 2018	Record of deaths	Several cities in Spain	1980-2015	Heat	The findings showed that the risk of mortality due to respiratory diseases was high, particularly among women. In Spain, heat vulnerability decreased as a result of enhanced healthcare services, air conditioning use, and effective public health measures.	High
Huber et al., 2024	Daily all-cause mortality linked to daily mean temperatures	Germany	2000-2023	Heat	During the summer of 2022, around 9,100 deaths in Germany were linked to extreme heat exposure.	Moderate
Chesini et al., 2022	22 million residents	Argentina	2013-2014	Heat waves	This study demonstrated that high mortality rates were mainly associated with respiratory, cardiovascular, diabetes, and renal illnesses. People above 60 years old were particularly affected.	High
Baker et al., 2024	Population of about 10 million (8 million adults)	Los Angeles County	1/1/2014 to 12/31/2019	Heat waves	Moderate heat risk was associated with an increase in mortality, confirming the significant impact of heat events on death rates.	Moderate

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Oray et al., 2018	ED visits and mortality rates	Izmir, Turkey	17th and 25th June 2016	Heat waves	During periods of extreme heat, an increase in both emergency department visits and in-hospital death rates is observed. Therefore, the implementation of effective adaptation strategies is required.	Moderate
Yezli et al., 2024	Rates of HS & HE (Two million people from over 180 countries)	Mecca, Saudi Arabia	Mecca meteorological data (1980–2021) and the incidence of HS and HE during Hajj (1980–2019)	Heat waves	High ambient temperatures show a strong correlation with higher incidence rates of heat stroke (HS) and heat exhaustion (HE).	Moderate
Alho et al., 2024	Hospital admissions	Portugal	2000-2018	Heat waves	Heatwaves have been significantly linked to elevated hospitalization rates for all major health conditions and across all age demographics.	Moderate
Tabassum et al., 2019	Data on hospital	Pakistan	20-27 June 2015	Heat (heat stroke)	During the heatwave period, 315 patients visited the Emergency Room (ER). Some of them were expired, but the majority survived. Among them, 55% were men, while 60% of patients were fully mobile.	Low
Green et al., 2016	Civil deaths in England and Wales	England & Wales	2013 summer	Heatwaves	In 2013, during a heatwave period, 195 deaths were recorded among individuals aged 65 and over.	Moderate
Figgs et al., 2019	Admissions to Douglas County	Douglas County, NE	2011-2012	Heatwave	Asthma diagnosis in the emergency department did not show a significant increase in 2012 compared to 2011. However, the risk was higher among individuals under 19 years old and among African American individuals, after adjusting for exposure to heatwaves.	Moderate
Figgs et al., 2020	Admissions to Douglas County	Douglas County, NE	2011-2012	Heatwave	During the 2012 risk period, females had almost 4 times more odds of developing chronic bronchitis at emergency department in comparison with females during the equivalent period in 2011.	High
Bhatta et al., 2020	366 research participants	Nepalgunj Sub-metropolitan	June to December 2019	Heat	In this study, most participants showed symptoms associated with heat exposure.	Moderate
He et al., 2023	Record of deaths in several Chinese regions	China	2013-2019	Ambient heat	The results show the association between elevated summer temperatures and a greater likelihood of accidental mortality. The findings demonstrate that the risk is notably higher among males and younger individuals, suggesting that existing assessments of climate change's health	High

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					impacts may underestimate the risks, especially for younger demographics.	
Oheneba-Dornyo et al., 2022	Malaria cases in several regions of Ghana	Ghana	January 2012 to May 2017	Heat and rainfall	In the region of Ghana, higher maximum temperatures exhibit a statistically significant negative effect on malaria incidence, while rainfall—lagged by two months—shows a statistically significant positive effect.	Moderate
Vaidyanathan et al., 2020	Record of deaths	United States	2004-2018	Heat	Exposure to heat contributed to deaths associated with specific chronic health conditions and various external causes.	High
Mohammadia et al., 2019	Working in palm groves	Jiroft, Southeastern Iran	August to September, 2017	Heat	The findings of this study showed that date harvesters were exposed to heat stress levels exceeding the WBGT reference limit set by the American Conference of Governmental Industrial Hygienists (ACGIH). In the palm groves of Jiroft, harvesters indicated a low level of physiological strain and a moderate level of perceived strain due to heat exposure.	Moderate
Tripp et al., 2015	Athletes at different high schools in Florida	Florida	August-October 2013	Heat	The incidence of exertional heat illnesses (EHIs) peaked in August. Training sessions during that month which exceeded the recommended duration of three hours, were linked to an increased risk of heat-related illnesses. Overall, the rate of EHIs among the high school football players observed in the study was lower than the rates reported for collegiate football athletes in the same region.	Moderate
Gasparrini et al., 2015	Analysis of premature deaths	384 locations (13 countries)	1985-2012	Non-optimum ambient temperature	A total of 7.71% of all recorded deaths were associated with non-optimal temperatures. Low temperatures accounted for a significantly higher rate of these deaths compared to heat. The proportion of deaths related to non-optimal temperatures differed across countries.	High
Achebak et al., 2023	All-cause mortality	8 prov-inces in Spain	1980-2018	Heat and cold	High vulnerability of mortality related to cold conditions is presented among older individuals. Demographic and	High

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					socioeconomic factors play a significant role in vulnerability of mortality related to heat- and cold.	
Rogne et al., 2024	California birth records	California	Jan 1, 1988, to Dec 31, 2015	High ambient temperature	The highest relation between ambient temperature and the risk of acute lymphoblastic leukemia occurred during the 8th week of gestation, with a 5°C rise in temperature linked to a 1.07% increase in the odds ratio.	High
Kienbacher et al., 2022	1109 adults' patients with STEMI	Austria	March 2012 to July 2017	Heat or cold exposure	On cold days, 85% of patients with STEMI were male, whereas the proportion was lower on hot days (71%) and on days with moderate temperatures (72%). Warm days did not show any notable differences between genders.	High
Ling-Shuang et al., 2020	Record of deaths per day	70 counties in Hunan, China	1 January 2013 to 31 December 2017	Non-optimum Ambient Temperature	Environmental temperature contributed significantly to the burden of years of life lost (YLL), accounting for 10.73% of YLL from non-accidental deaths and 16.44% from cardiovascular-related deaths.	High
Miao et al., 2024	27712 patients with fatal AMI	Xuzhou, China	January 1, 2018, to December 31, 2020	Temperature	The risk of fatal acute myocardial infarction (AMI) rises significantly during cold weather, while no such increase is observed in hot days.	High
Yoshizawa et al., 2023	Out-of-hospital natural deaths	Osaka, Japan	2018 to 2022	Temperature	The relative risk of out-of-hospital non-COVID-19 deaths increased at both cold and hot temperatures in the period following the COVID-19 pandemic, compared to the period before it. This suggests a high sensitivity to temperature extremes after the pandemic.	Moderate
Onozuka et al., 2016	Daily data on out-of-hospital cardiac arrest OHCAs	47 prefectures of Japan	2005-2014	Temperature	Exposure to extreme temperatures is linked to a higher risk of out-of-hospital cardiac arrest (OHCA).	High
Wen et al., 2023	Weather data in 181 towns	China	2015	Temperature	This study showed that long-term exposure to temperature variability (TV) was linked to the prevalence of major diseases among older adults.	Moderate
Kunene et al., 2023	Record of diarrheal cases per day in hospitals	Rural site in South Africa	2007-2016	Temperature	An increase in average daily temperature was associated with a higher rate of hospital admissions for diarrhea disease, affecting individuals of all ages, with a notable impact on those over the age of five.	Moderate

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Wen et al., 2024	Outpatient and inpatient admissions	Thailand	January 2013 to August 2019	Temperature	According to the findings, both low and high temperatures effect on hospital admissions, with the strongest effects observed among females, as well as children and adolescents aged between 0 and 19 years.	High
Jamshidnezhad et al., 2021	31 provinces of Iran	Iran	04/03/2020 and 05/05/2020	Temperature	This study clearly demonstrated that as outdoor temperatures rise, the use of air conditioning to maintain indoor comfort, becomes inevitable. Consequently, this may contribute to an increase in the number of confirmed COVID-19 cases.	Moderate
Meiman et al., 2015	Record of deaths due to hypothermia	United States	2003-2013	Cold	In the United States, extreme cold contributes to an increase of weather-related deaths. Factors that increase the risk of hypothermia-related mortality include older age, mental health disorders, sex, and drug intoxication.	Moderate
Lelieveld et al., 2023	Globally deaths	Global	2019	Air pollution (fine	Fine particulate matter and ozone air pollution are estimated to contribute to approximately 8.34 million excess deaths globally per year.	Moderate
Zoran et al., 2023	Record of COVID cases	Tokyo	March 1, 2020-2022, 1 October	Air quality and climate variability	The elevated daily COVID-19 cases and death rates observed in Tokyo, during the seventh wave may be linked to increased concentrations of air pollutants and viral pathogens.	Low
Stafoggia et al., 2023	Population data (people aged 30 years and over)	Italy	2016-2019	Air pollution & high temperature	All-cause mortality is associated with the effects of acute exposure to air temperature, while cause-specific mortality is primarily linked to the long-term impacts of chronic exposure to air pollution.	High
Tian et al., 2020	CVD deaths	Shanghai, China	1 January 2012 and 31 December 2014	Ambient fine particulate matter (PM2.5) and extreme weather conditions	Short-term exposure to PM2.5 was linked to an increased risk of cardiovascular mortality, with evidence of lagged effects. However, cold weather may present a potential antagonistic interaction of PM2.5.	High
Parmar et al., 2019	Household women	Nigeria	January 2019	Air pollution	In Nigeria, the concentration of particulate matter (PM), carbon monoxide (CO), and thermal stress, are unhealthy, with women and young children being the most vulnerable groups.	Moderate
Yussuf et al., 2023	The data obtained was temporal and averaged	Mombasa, Nakuru, and Nairobi	1990-2020	Air pollution	The effect of PM2.5, carbon monoxide, and sulfur dioxide is different on lower	Moderate

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	monthly from the sources				respiratory infections among children across all cities.	
Korsiak et al., 2022	2 million people	Canada	1996-2015	Wildfires	Exposure to wildfire smoke increases the incidence of lung cancer and brain tumors.	High
Hutchinson et al., 2018	Medi-Cal recipients	San Diego	2007	Wildfires	During wildfires, some respiratory diseases, such as asthma, increased among vulnerable populations.	Moderate
Blando et al., 2022	Medical records of a clinic	A small town less than 40,000 residents (United States)	1st fire (from 9 June through 7 October 2008) & 2nd fire (from 4 August through 11 October 2011)	Wildfires	A decline in peak respiratory flow was observed among allergy clinic patients one year following each wildfire incident.	Moderate
Karmarkar et al., 2020	People in evacuation shelters	California	November 2018	Wildfires	Between November 8 and 30, a total of 292 cases of norovirus illness, including 16 confirmed and 276 probable cases, were identified among a fluctuating population of approximately 1,100 evacuees across eight of nine shelters.	High
Kouis et al., 2021	211 children	Cyprus and Greece-Crete	February-May 2019 February-May 2020 February-May 2021	Desert dust	Dust outbreaks with high PM10 levels are linked to increases in overall and specific mortality rates, as well as higher hospital admissions for asthma and chronic obstructive pulmonary disease (COPD).	High
Baten et al., 2020	17863 ever-married women	Bangladesh	2011-2014	Floods	The study reveals that floods can have a detrimental effect on the utilization of MNH. Additionally, repeated floods have a worse effect on MNH utilization than incidental floods.	Moderate
Wettstein et al., 2025	Exposure of extreme flood events	United States	January 1, 2008, to December 31, 2017	Floods	Increased health care use and costs are linked with flood exposure, indicating the necessity for targeted public health strategies and enhanced disaster preparedness, particularly for older adults.	High
Zhu et al., 2024	Demographic and Health data on birth mortality	Africa	1990-2020	Floods	Exposure to floods is linked to high risks of infant mortality across several time periods, with these risks remaining high for up to four years after the flood event.	High
Stamos et al., 2024	International disaster and fatality datasets	Mediterranean regions	1900-2023 and 1980-2023	Floods	Flood mortality is related to geographic variations and generally inconclusive temporal trends.	Moderate
Osei et al., 2022	Population	53 African countries	2000-2018	Floods	This study showed that foods lead to destruction of health infrastructure and to the dispersion of illnesses, thereby reducing life expectancy. In 53 African	Moderate

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					countries, the mortality rate increases due to floods.	
Rerolle et al., 2023	Almost 600000 mothers interviewed in several regions using surveys	Tibet, Nepal, Bhutan, Bangladesh, and northern India	1988-2017	Floods	High-resolution data on flood risk and population distribution reveal an excess of infant deaths in flood-prone regions of Bangladesh over the past 30 years, with notable variations in the burden across different regions.	High
Ferdous et al., 2020	Flood mortality rate in a region of Bangladesh	Bangladesh	2017	Floods	During the 2017 flooding in Bangladesh, regions with lower levels of flood protection presented lower mortality rates.	Moderate
Graham et al., 2019	Adult Psychiatric Morbidity Survey	England	May 2014 to September 2015	Floods	Floods and storms are closely linked to common mental disorders due to its high frequency and intensity. For this reason, community resilience and disaster preparedness have to be enhanced.	High
Bouwer et al., 2018	Data on flood events, and related number of diseases and mortality	Belgium	before & after 1980	Floods	Flash floods cause the highest mortality rate, following by storm surges and river floods.	Moderate
Liu et al., 2017	Data of bacillary dysentery illness per month	Guangxi, China	January 2004 to December 2010	Floods	Flood events can cause an increase in bacillary dysentery diseases. By 2030, an 8.0% increase is expected in Guangxi.	High
Vanasse et al., 2016	Adult populations	Quebec, Canada	2010-2011	Floods	Previous studies have shown a connection between natural disasters and cardiovascular disease (CVD), but this study suggests that the number of individuals impacted by the flood is limited.	Moderate
Thiele-Eich et al., 2015	Record of deaths	Bangladesh	1909-2009	Floods	Between the period 2003-2007, two intense flood events are recorded in 2004 and 2004. The increased water levels are not related to the high mortality rate, as a good level of adaptation and effective flood management are in place.	Moderate
Aik et al., 2020	Record of diarrhea disease	Singapore	2005-2018	Climate variability (Humidity, ambient air temperature)	Diarrheal diseases are highly seasonal and are closely linked to climate variability.	High
Gill et al., 2021	Traumatic injuries and deaths caused by natural disasters	United States	2014-2019	Natural Disasters (Floods, wildfires, hurricanes and tropical storms)	The number of traumatic injuries and fatalities from certain natural disasters in the United States has significantly increased between 2014 and 2019.	Moderate
Tawiah et al., 2023	Children at hospitals	Bono Region, Ghana	2010-2021	Rainfall, humidity, and temperature	The findings show that both malaria cases conducted and	High

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	climate parameters have a significant impact on confirmed malaria cases among children under 5 years.

3.2. Characteristics of Included Studies

The content of the selected articles was thoroughly analyzed to identify the geographical origin of the studies. As depicted in Figure 2, the majority of studies-representing the 38% of total articles-were conducted in Asia, followed by those from America. Europe ranked third, with eleven studies, while Africa followed with seven. Additionally, two studies (3% of the total) were conducted across several global regions.

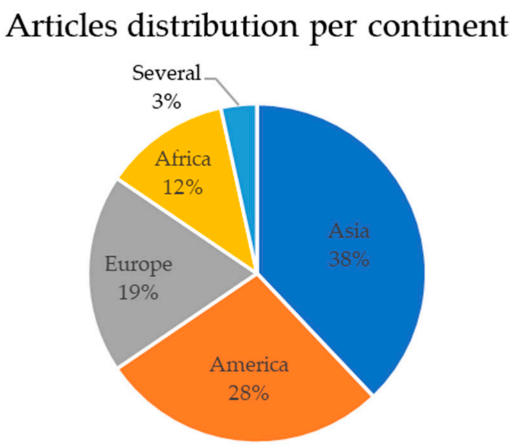

Figure 2. Articles distribution per continent.

In detail, the articles analyzed in this study were classified according to their country of origin. The United States accounted for the highest number of publications (12), followed by multinational regions (8) and China (6), as illustrated in Figure 3.

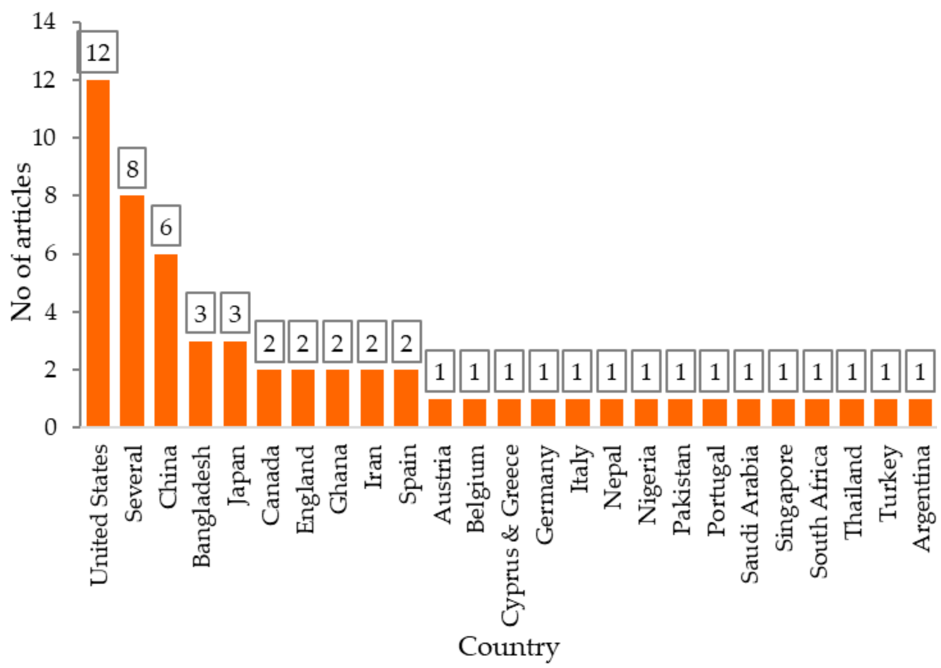

Figure 3. Number of articles per country.

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3.3. Distribution of Articles Based on Climate Parameter

In this section, the 57 articles are categorized based on the climate parameter that was evaluated. A total of six climate-related factors were identified across the current systematic review: temperature, floods, humidity, air pollution, wildfires and dust. Figure 4 presents the number of articles that addressed each of these parameters. As expected, several studies examined more than one climate factor; therefore, the cumulative number of articles shown in Figure 4 exceeds the sum of 57. As presented in Figure 4, most articles investigated the effect of temperature on human health, involving heat, cold as well as temperature variation. Flooding was the second most frequently studied parameter, addressed in 17 articles. The effect of air pollution and humidity was each examined in seven studies, while wildfires were explored in four. Only one article studied the desert dust effect on human health.

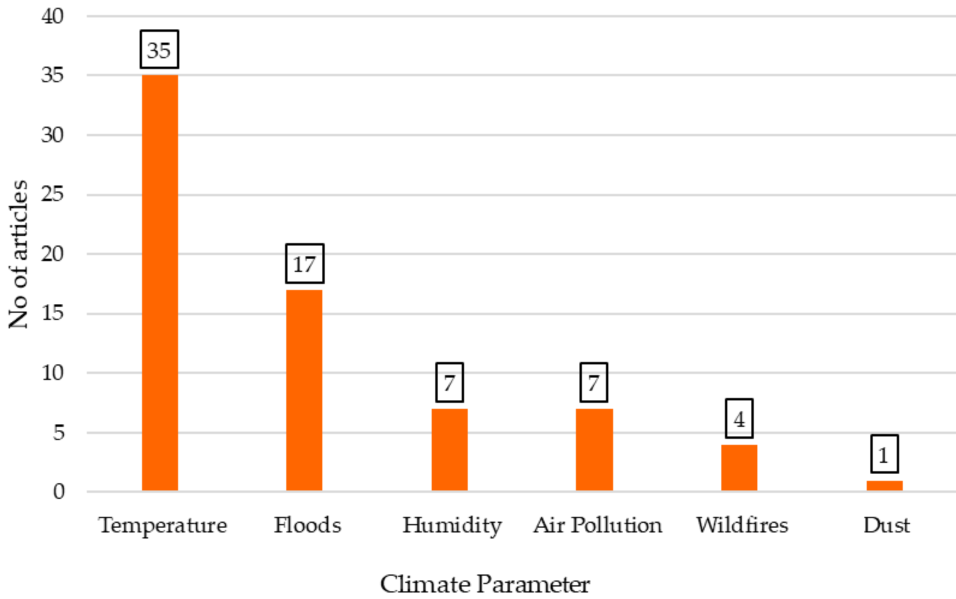

Figure 4. Number of articles addressing each climate parameter.

3.3.1. Temperature

The majority of the studies – thirty-five in total- indicated the effect of temperature on human health. This section presents three key parameters of temperature-related effect: heat, cold and temperature variation.

Over the last years concerns about the continuous temperature rise as well as the increase in the frequency, intensity, and duration of extreme heat events have increased. [25] Several studies showed that exposure to high ambient temperature increases the risk of heatstroke, dehydration, cardiovascular and respiratory diseases. [1,21,22,26–29] Regarding respiratory diseases, it is proven that asthma and chronic bronchitis diagnosis in the emergency department (ED) was 1.23 and 1.61 times higher during a heatwave period, respectively. [30,31] Additionally, various other symptoms such as headaches, dizziness, dry skin/rashes, and heavy sweating are reported during extreme heat days, which are significantly associated with several demographic factors like sex, education level, and income. [1] Another interesting study conducted by Oheneba-Dornyo et al., demonstrated that elevated temperature is more likely to have a significant decrease in malaria incidences. [23] This is attributed to the fact that high temperatures may reduce mosquito survival rates and parasite development, leading to low transmission. [23,32] In 2019, Mohammadia et al. conducted a study for harvesting workers in Iran a region known for hot climate conditions and the results showed that workers face significant heat stress including increased heart rate, core body temperature, and sweating rate, due to intense solar radiation and high ambient temperatures during the harvesting season. [17] Additionally, exposure to extreme heat has been consistently associated with an increased mortality rate, as demonstrated by numerous recent studies. [3,12,19,20,22,33] In 2024, Huber et al. estimated approximately 9,100 heat-related deaths in Germany during the summer of 2022, while Chesini et al. identified 1,877 excess deaths during the HWs in Argentina, corresponding to a 23% increase in mortality risk. [34,35] According to Gasparrini et al., who conducted a large-scale observational study, data from 384 locations across 13 countries, showed that heat was responsible for 0.42% of all recorded deaths. [36] Another study showed the high temperature effect during pregnancy, proving that maternal exposure to high ambient temperatures may lead to increased oxidative stress and inflammation, which could disrupt fetal development and contribute to pathogenesis. [37]

On the contrary cold temperatures have been shown to contribute to a significantly higher mortality burden compared to heat. [36,38] Specifically, cold-related deaths accounted for 7.29% of total mortality, whereas heat accounted for only 0.42%. [36] This finding is also confirmed by the Ling-Shuang et al. study which indicates that the majority of years of life lost (YLL) due to temperature exposure were attributed to cold rather than heat. [39] Moreover, exposure to extremely cold temperatures (−2 °C) within a 30-day period was associated with a 4.66 times higher risk of fatal acute myocardial infarction (AMI), influencing mainly women and individuals over 65 years of age. [38] In the contrary, Kienbacher et al. found that 85% of ST-elevation myocardial infarction (STEMI) patients were referring to males on cold days, compared to 71% on hot days and 72% on days with moderate temperatures. [40]

From the above studies that referred to heat and cold factors, it has been shown that temperature variability is significantly related to increased rates of mortality and hospital admissions. [8,11,41] Chronic exposure to temperature variability is significantly correlated with various diseases, including asthma, chronic lung diseases, stomach diseases, arthritis, cardio-cerebrovascular diseases and cataract. [8] Moreover, two studies mentioned a strong seasonal influence in diarrhea disease indicating that for every 1°C increase in average daily temperature, there was a 6% increase in hospital admissions for diarrhea across all age groups. [16,42] Moreover, Jamshidnezhad et al. indicated that ambient temperature factor affects the transmission rates of COVID-19. [43] Finally, another study pointed out that ambient temperature was responsible for 10.73% of non-accidental deaths and 16.44% of cardiovascular deaths, while its impact on respiratory disease mortality was not statistically significant. [39]

3.3.2. Air Pollution

Air pollution is characterized as one of the main environmental risk factors extremely relevant for public health in recent years. [27] The effect of air pollution on human morbidity and mortality is evaluated by seven articles. In 2023, Lelieveld et al. proved that 8.34 million deaths per year is attributed to air pollution and fine particulate. [44] A similar analysis depicting high mortality rate after chronic exposure to particulate matters (PM2.5) in Italy was shown by Stafoggia et al. [27] High rate of deaths is attributed mainly to cardiovascular mortality which increases in high PM2.5 concentration. [6] Additionally, Yussuf et al. found that the exposure to harmful pollutants, mainly PM2.5, is likely to worsen respiratory health. [10] Two studies examine the air pollution effect on COVID-19 depicting that the highest rates of the recorded COVID-19 cases per day as well as death cases may be attributed to high levels of air pollution. [43,45] Finally, another study conducted in Nigeria by Parmar et al., proved that the high concentration levels of both Carbon Oxides (CO) and PMs can lead to thermal stress. The importance of thermal stress is not recognized in the occupational sector in the tropical and subtropical regions. [29]

3.3.3. Wildfires

Four studies examined the relationship between wildfires and human health. Korsiak et al. found a significant association between wildfires and lung cancer, indicating an almost 5% higher cases of lung cancer in individuals who were exposed to wildfires over the past 10 years in comparison to unexposed populations. [46] Additionally, some other respiratory diseases like asthma

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and allergic sensitization are related to wildfires, especially in the case of children below 4 years old presenting a 70% increase in respiratory-related ED visits. [13,14] Brain tumors are also increased by 4% for individuals exposed to wildfires within 50 km of their residences the past 10 years. [46] According to Karmarkar et al. gastroenteric outbreaks such as from norovirus also arise among wildfire evacuation shelter populations due to the lack of surveillance, isolation protocols, and sanitation practices. [47] All these wildfire effects on human health are mainly attributed to carcinogenic pollutants released during wildfires, including heavy metals, benzene, formaldehyde and polycyclic aromatic hydrocarbons. [46] However, no significant associations were found between wildfire exposure and haematological cancers such as leukaemia, non-Hodgkin lymphoma and multiple myeloma. [46]

3.3.4. Dust

One study demonstrated associations of PM_{10} during DDS outbreaks with increased rate of hospital admissions of asthma and COPD and mortality in Cyprus and Greece, particularly in the region of Crete. [15] According to the results, children with asthma are considered one of the most vulnerable groups to DDS exposure. [15]

3.3.5. Floods

Seventeen articles studied the health effects of floods and rainfalls including except for mortality rate increase, the outbreak of several diseases such as respiratory infections, gastrointestinal illnesses, trauma, malaria, gastrointestinal illnesses (bacillary dysentery or diarrhea) and acute CVD. [2,10,23,32,42,48–57,59] Two studies revealed a statistically significant positive association between flood and malaria cases due to favorable breeding conditions created for mosquitoes, leading to higher transmission rates after a delay. [23,32] Common mental disorders (CMDs), such as depression, anxiety and trauma are also related to flood events increasing psychiatric hospitalizations, especially for the people whose home was damaged due to extreme flood events. [49,55] Moreover, according to Osei et al., floods have also long-term consequences, contributing to chronic health burdens and affecting nutritional status, which can further decrease life expectancy. [52] Except for the morbidity effect of floods, various studies confirm the mortality data linked to flood events, especially on West and Central Africa as well as on Mediterranean countries in Europe, on Argentina and on Southeast Asia due to factors like inadequate infrastructure and limited early warning systems. [50,51,52,54,56,59]

Finally, another interesting finding by Baten et al. refers to flooding effect on maternal and newborn healthcare (MNH) services leading mothers and their newborns in reduced access to adequate antenatal care from skilled providers, institutional deliveries, cesarean sections, and postnatal checkups. [48] Additionally, flooding can disrupt access to healthcare facilities, causing delays in treatment and worsening health outcomes. [49] For this reason, high rate of infant mortality, particularly in female infants, is unfortunately observed. These incidents are mainly presented to infants, of which mothers have lower education background, and families residing in rural areas with inadequate water and sanitation infrastructure. [50,52] Rerolle et al. revealed that children born during the rainy season presented a higher risk in comparison with those born in a dry season. [53]

3.3.6. Humidity

The effect of humidity parameter on human health was evaluated by seven studies. According to Yezli et al. and Tripp et al., the risk of heat-related illnesses such as HS and heat exhaustion (HE) is strongly correlated with high temperatures and humidity. [60, 61] On the contrary, low humidity level is associated with increased respiratory issues such as asthma. [30,31] As the spread of respiratory viruses is closely related to high humidity, it has been stated that the combination of humidity and low temperature provide the ideal conditions for the transmission and stability of the COVID-19 virus. [43] Additionally, Aik et al. showed that a 10% increase in relative humidity is associated with a 3% increase in diarrhea disease reports. [42] Finally, Tawiah et al. demonstrated that humidity factor does not show a significant association with confirmed malaria cases in the study. [32]

3.4. Classification of Articles by Health Outcomes: Mortality and Morbidity

Specifically, 35 articles examine fatal outcomes, while 41 focus on disease-related (morbidity) impacts. Several studies address both outcomes.

3.4.1. Mortality

Climate change significantly impacts human mortality through increased exposure to non-optimal ambient conditions involving mainly the factors of temperature and air pollution. [25,34,36,44,62] According to several studies, deaths rate is significantly linked to temperature-related causes, either hot or cold conditions, indicating for instance an increase between 1 and 23% in mortality rate during the HW periods. [3,19,33,35] Moreover, four studies found out deaths linked to air pollution like fine $PM_{2.5}$, Nitrogen Dioxides (NO_2), carbon monoxide, sulfur dioxide, and ozone (O_3) compounds which are related to CVDs like arterial hypertension, stroke, neurodegenerative diseases, COPD and ischemic heart disease. [6,10,27,44] According to several studies, the impact of climate change in mortality rates varies geographically and are intensified among vulnerable people such as individuals with pre-existing health conditions, the elderly, and those living in low-income regions. [21,35,36,38,39,49] Additionally, some other studies examined and confirmed that the mortality rate was higher in various natural disasters such as tornadoes, wildfires, hurricanes, and tropical storms. [2,26] Finally, the studies of Zhu et al. and Rerolle et al. demonstrated an association between extreme floods and infant mortality indicating that the ratio deaths per births ratio during extreme floods is almost 53% higher than the corresponding one during large floods. [50,53]

3.4.2. Morbidity

This section presents the effects of climate change on human morbidity, focusing on specific disease categories such as cardiovascular, respiratory, gastrointestinal, and mental disorders, as well as injuries and malaria. Additionally, another section involving other diseases such as cataract, hypertension, diabetes, arthritis, cancer, and reproductive diseases is presented. As illustrated in Figure 5, respiratory illnesses are the most frequently examined, followed by cardiovascular and gastrointestinal diseases. Each disease category is discussed in detail in the subsequent sections.

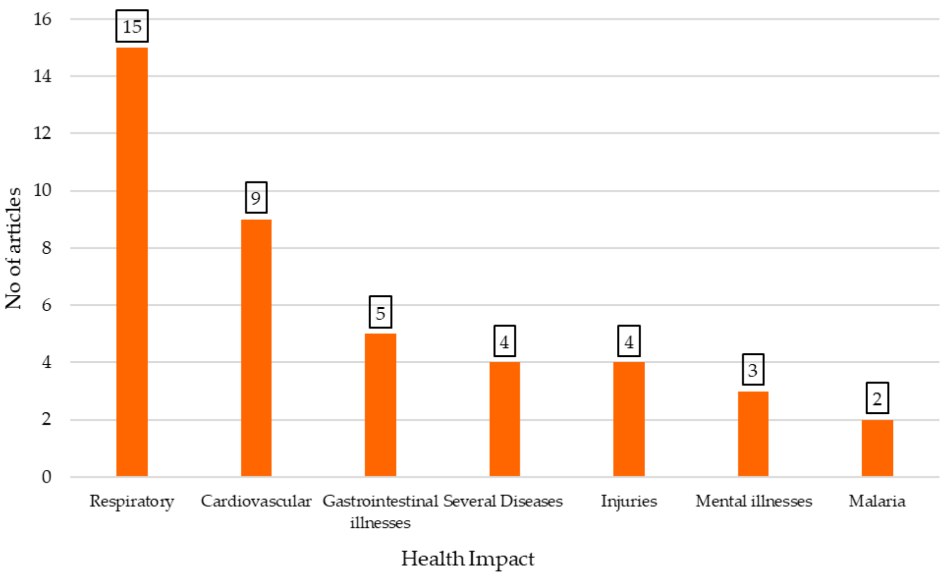

Figure 5. Number of articles addressing each disease.

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3.4.2.1. Cardiovascular Morbidity

CVDs are increasingly influenced by environmental and climate-related factors, particularly extreme temperatures and temperature variability. [8,22,29] Two studies demonstrated that heatwaves and high ambient temperatures have been associated with increased cardiovascular hospitalizations. [13,26] In 2022, Kienbacher et al. reported that extremely cold temperatures are linked to acute cardiovascular events such as AMI. [40] Exposure to low temperature within 30 days led to an increase in fatal AMI risk mainly in women and in individuals aged above 65. [8,38] Moreover, the study by Onozuka et al. showed that extreme temperatures -low and high- are associated with a high risk of out-of-hospital cardiac arrest (OHCA) in Japan. [11] A study conducted in the United States, during 2004–2018 provided a comprehensive analysis of CVD like heart diseases and hypertension associated with natural heat exposure over a 15-year period. [22] Finally, individuals with a history of CVD had up to a 69% increased risk of acute CVD during the flood period. [58]

3.4.2.2. Respiratory Morbidity

The majority of articles -fifteen in total- refers to the respiratory diseases due to climate change as respiratory health is highly sensitive to climatic conditions, particularly extreme temperatures, air pollution, flood and humidity fluctuations. [9,29,35,44,49] The main climate factor which causes or exacerbates respiratory diseases is air pollution, due to either fossil fuels use or wildfires. [43] During wildfires, carcinogenic pollutants can cause severe respiratory diseases like lung cancer or less severe like asthma and allergic sensitization. [13,14,46] Asthma symptoms are intensively exacerbated during desert dust exposure as well as during HWs or periods with temperature variability. [8,15,30] Moreover, according to a study conducted in the USA, ED diagnoses of chronic bronchitis are increased during HWs depending on sex and age. [31] Another study showed an 18.9% increase in daily hospital visits during heatwave periods compared to non-heatwave days with respiratory disorders to correspond 25.3% of total diseases. [26] In 2023, Yussuf et al. studied the influence of seasonal variations, such as temperature and rainfall, in the annual fluctuation of pediatric respiratory infection cases in urban Kenyan settings. The study highlights the combined impact of air pollution and climate change on children's respiratory health. [10]

3.4.2.3. Gastrointestinal Disease

Kunene et al. investigated the effect of temperature on hospitalization due to diarrhea concluded that 1 °C rise in average daily temperature corresponds to a 6% increase in hospitalizations for diarrhea among individuals of all ages, and a 4% increase among those older than 5 years. [16] Moreover, according to the study of Oheneba-Dornyo et al. the diarrheal disease rate is also increased about 4% in an increase of 10% in relative humidity. [23] Flooding events also contribute to an increase of hospitalizations especially for gastrointestinal illnesses such as diarrhea and bacillary dysentery. [49,57] Finally, an outbreak of Norovirus illness among shelter populations after an extreme wildfire evacuation is reported due to the lack of sanitation practices in California during November 2018. [49]

3.4.2.4. Mental Illnesses

It is worth mentioning that except for physical illnesses, three studies referred to the association between two extreme environmental factors and mental diseases. According to Meiman et al., hypothermia is closely linked to mortality, with major risk factors including substance intoxication, social isolation and mental health disorders. [20] Additionally, an increased rate of hospitalizations following floods is observed leading to mental health emergencies (stress and trauma) and to increased psychiatric hospitalizations. [49] After an extreme flood phenomenon in England, the individuals whose homes were damaged, had a higher risk of CMDs, such as anxiety and depression, compared to those who were not affected by this damage. [55]

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3.4.2.5. Data on Climate Change and Injuries

Heat and extreme natural disasters like floods cause sometimes injuries, as examined by several studies. [2,12,49,52] He et al. record 711,929 accidental death such as traffic accidents, falls, drownings, and other unintentional injuries during 2013-2019 in China, confirming an association between elevated temperatures and high risk of accidental deaths. [12] Moreover, two studies showed an increase in hospitalizations due to injuries following floods in the United States and in Africa. [49,52]

3.4.2.6. Heat Illnesses

In 2019, Parmar et al. investigated the heat stress and air pollutants link among low-income women business owners in Nigeria, indicating significant thermal stress cases after a prolonged exposure to high temperatures. [29] One year later, Bhatta et al. demonstrated that heat stress during a HW period, depends on sex, education level, and income were significantly associated. [1] Moreover, harvest workers in Iran felt uncomfortable, fatigued, and thirsty, while heart rate, core body temperature, and sweating rate were also increasing after a heat exposure. [17] Trip et al. investigated the incidence of exceptional heat illnesses (EHIs) among the football trainers in high school presenting a close association of high humidity and temperature with the rate of heat-related illnesses. [61]

3.4.2.7. Malaria

Two articles examined the malaria illness indicating that increased floods are significantly associated with malaria cases in the region of Ghana. [23,32] On the contrary, the increase of temperature is linked to a decrease of confirmed malaria cases, as temperature probably inhibits optimal conditions for mosquito survival or parasite development. [23,32]

3.4.2.8. Data on Climate Change and Additional Health Conditions

Exposure to wildfires within 50 km of an individual's residence has been associated with an increased risk of certain diseases, including lung cancer and brain tumors. However, no significant association was observed between wildfire exposure and cancers such as leukemia, multiple myeloma, or non-Hodgkin lymphoma. [46] Moreover, Wen et al. found that a long-term exposure to temperature variability is significantly related to high prevalence of several diseases such as asthma, diabetes, stomach diseases, hypertension, cataract, cardio-cerebrovascular diseases, chronic lung disease, reproductive diseases, cancer, and arthritis. [8] In 2023, Rogne et al. confirmed the link between high ambient temperatures during pregnancy and the risk of acute lymphoblastic leukemia (ALL) in children, while Baten et al. validated the effect of floods on the MNH system in Bangladesh. [37,48]

4. Discussion

The findings of this systematic review reaffirm the substantial impact of climate related factors —particularly temperature extremes, air pollution, floods, wildfires, humidity, and desert dust — on human morbidity and mortality. These results align with previous large-scale reviews and public health statements, such as those by the Intergovernmental Panel on Climate Change (IPCC) and the World Health Organization, which emphasize the disproportionate burden of climate change on vulnerable populations, including older adults, children, and people with pre-existing chronic diseases [63,64,65].

A significant body of the literature has already confirmed the link between extreme heat and increased mortality, especially from cardiovascular and respiratory causes [66,67,68]. Gasparrini et al., in a landmark multi-country analysis, estimated that non-optimal temperatures contribute to 7.7% of global mortality, with cold-related deaths surpassing heat-related ones [36]. Similarly, our review found that both high and low temperatures exert serious physiological stress, particularly on cardiovascular and pulmonary systems.

Compared to earlier reviews (Watts et al., 2021, The Lancet Countdown [69,70]), our work expands on under-represented parameters such as dust storms and their microbial content (e.g., fungi, bacteria), which were associated with exacerbation of asthma and COPD. This complements regional findings from the Eastern Mediterranean and North Africa, where Saharan desert dust storms are frequent [71]. While many existing studies focus on temperature and air pollution, fewer have addressed desert dust as a distinct environmental hazard with public health implications.

Abdul-Nabi et al. investigated the climate change and its environmental and health impacts from 2015 to 2022. In this study a wide range of health impacts caused by climate-related events, including heatwaves, floods, wildfires, and air pollution were presented. Similarly, the current systematic review found a close association between these extreme phenomena and human morbidity and mortality. [72] Moreover, Archad et al. mentioned the impact of heatwaves on mortality and morbidity especially for the elderly and children. This trend is also confirmed by the current review. [73] Another review aligned to the current one showed that several demographic parameters, such as income, play a determining role on the effect of climate change on human health. [74] Additionally, Rocque et al. examined the role of urban green spaces in the reduction of heat-related health effects, while this systematic review does not focus on this issue. [75]

Regarding floods, our review corroborates previous systematic analyses (e.g., Alderman et al. [76]; Stanke et al. [77]) by highlighting their multifaceted effects—not only on infectious diseases but also on mental health and maternal care access. Recent studies have underlined the long-term psychological impact of climate disasters, including depression and PTSD among flood victims [78], which supports the need for integrated disaster-response strategies that include mental health services.

Moreover, wildfires emerge as a growing concern. A review by D'Evelyn et al. outcomes, especially among marginalized populations [4]. Our review findings support this by documenting increased risks for lung cancer, asthma exacerbations, and even norovirus outbreaks in evacuation shelters following wildfires.

Molecular Mechanisms Linking Climate-Related Environmental Stressors to Cardiovascular Morbidity and Mortality

Emerging evidence suggests that environmental stressors such as extreme heat, air pollution, and wildfires exert significant cardiovascular effects through well-defined molecular mechanisms. These mechanisms involve the upregulation of pro-inflammatory cytokines, oxidative stress pathways, endothelial dysfunction, and gene-environment interactions.

Exposure to fine particulate matter ($PM_{2.5}$) from pollution or biomass burning has been shown to trigger systemic inflammation by increasing levels of interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-α), and C-reactive protein (CRP). These inflammatory mediators can contribute to atherosclerosis progression and acute coronary events [79,80].

Oxidative stress also plays a central role. Environmental factors such as heatwaves and pollutants promote the generation of reactive oxygen species (ROS), which damage vascular endothelium, impair nitric oxide signaling, and exacerbate myocardial ischemia. The activation of NADPH oxidase (NOX) enzymes is a key mediator in this process [81,82].

In addition, studies have shown that heat stress alters gene expression patterns related to cardiovascular regulation. Heat-induced activation of the hypothalamic-pituitary-adrenal (HPA) axis leads to elevated cortisol levels, which may influence cardiac autonomic control and metabolic responses [83,84].

MicroRNAs (miRNAs), particularly miR-21 and miR-155, have emerged as molecular regulators of cardiovascular inflammation in response to environmental insults, like exposure to pollutants. These epigenetic modulators alter gene expression profiles that influence endothelial cell behavior and inflammatory signaling [85,86].

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Furthermore, the expression of adhesion molecules such as ICAM-1 and VCAM-1 is increased under exposure to environmental pollutants, promoting leukocyte recruitment and vascular inflammation [87,88].

By synthesizing these molecular insights, the current review emphasizes the complex biological underpinnings of environmental cardiovascular risk and underscores the importance of incorporating molecular data into public health surveillance and adaptive strategies.

Novel Findings on Health Impacts and Inequities in the Climate Crisis

Notably, our review identifies reproductive and developmental risks—such as increased risk of acute lymphoblastic leukemia in children linked to high maternal exposure to ambient heat during pregnancy [89]. These findings add to a growing literature connecting climate stressors with epigenetic and developmental disruptions, a field still under explored in mainstream climate-health research.

At the same time, the current review focused on some additional health consequences that are not examined previously. For instance, hearing loss is related to environmental factors, while climate change can affect also, directly or indirectly, on mothers and their newborns health [18, 48].

In terms of public health preparedness, this review aligns with WHO's Operational Framework for Building Climate-Resilient Health Systems [90], which advocates for strengthened surveillance systems, health workforce training, and heat action plans. However, our findings indicate that implementation gaps remain significant, especially in low-resource settings where early warning systems and basic infrastructure are limited.

Furthermore, very few studies explicitly addressed health equity, although social determinants—such as low income, rural residence, or limited access to healthcare—recurred across the literature as amplifiers of vulnerability. This supports recent calls for "climate justice" frameworks that integrate environmental, social, and health equity policies [91].

Despite its strengths, our review is subject to some limitations. It focused, according to the purpose of the study, on peer-reviewed articles published in English from 2015 to 2025, possibly excluding valuable grey literature or earlier foundational work.

5. Conclusions

This systematic review demonstrates the association between six climate factors such as temperature, air pollution, humidity, floods, wildfires and dust on human mortality and morbidity.

Extreme temperatures -both heat and cold- as well as temperature variations, which are the most examined climate parameters, are significantly associated with high rate of mortality and morbidity, particularly affecting respiratory and cardiovascular health. Heatwaves are linked to the risk of heatstroke, dehydration, cardiovascular and respiratory diseases, while cold temperatures have been shown to contribute to a significantly higher mortality rate compared to heat.

Air pollution is identified as a major contributor to cardiovascular and respiratory diseases, with fine $PM_{2.5}$ and ozone playing a central role. Wildfires, floods, and dust storms further compound respiratory and gastrointestinal illnesses, while floods are also associated with increased mental health disorders, injuries, and maternal and neonatal health disruption.

Additionally, this systematic review highlights that in some cases vulnerable groups -like elderly, children, individuals with pre-existing health conditions, and those living in poverty or rural areas- are more affected by the health impacts of climate change.

Overall, the findings show the urgent need for stronger public health actions and climate-ready healthcare systems to mitigate the health risks related to climate change, improving the citizens' quality of life.

6. Future Directions

This review highlights the urgent need for interdisciplinary research exploring the multifaceted health impacts of climate change, with particular emphasis on cardiovascular disease as a leading cause of climate-related morbidity and mortality. Future studies should aim to clarify the biological and molecular mechanisms by which environmental stressors—such as heatwaves, air pollution, and extreme weather events—exacerbate cardiovascular risk, especially among vulnerable populations. At the same time, more robust data are needed on other underexplored health domains, including mental health, maternal outcomes, and chronic disease interactions, to capture the full scope of climate-induced health burdens.

Longitudinal and multi-country studies are essential to establish causal links and temporal patterns, and research efforts focused on bridging basic science with clinical application can support the integration of environmental risk factors into clinical risk assessment tools and public health strategies. Finally, assessing the effectiveness of adaptation measures—such as early warning systems, climate-resilient infrastructure, and patient-centered education—in mitigating health risks, particularly cardiovascular complications, will be critical to inform evidence-based clinical and policy interventions in the context of a changing climate.

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The following abbreviations are used in this manuscript:

CVD	Cardiovascular disease
COPD	Chronic obstructive pulmonary lung disease
WHO	World health organization
DDS	Desert dust storms
PRISMA	Preferred reporting items for systematic reviews and meta-analyses
ED	Emergency department
STEMI	ST-elevation myocardial infarction
AMI	Acute myocardial infarction
CO	Carbon oxides
PM	Particulate matter
CMDs	Common mental disorders
HWs	Heat waves
HE	Heat exhaustion
NO2	Nitrogen dioxide
OHCA	Out-of-hospital cardiac arrest
EHIs	Exertional heat illnesses
MNH	Maternal and newborn healthcare
PTSD	Post-traumatic stress disorder

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