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Climate Change Effects On Cardiopulmonary And Thermoregulatory Disease: A Scoping Review

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Abstract. *Climate change has become one of the most critical challenges affecting human health across the globe. This review explores the intricate relationship between environmental alterations and the rising prevalence of cardiopulmonary and thermoregulatory diseases. Rapid industrialization, deforestation, and greenhouse gas emissions have disrupted ecological balance, resulting in global warming, poor air quality, and extreme weather conditions. These factors significantly influence physiological systems, leading to increased incidence of heat stroke, hypertension, ischemic heart disease, asthma, and chronic obstructive pulmonary disease. The study integrates findings from epidemiological, environmental, and medical research to explain how temperature fluctuations, pollution, and humidity interact with biological responses. It also emphasizes the socio economic and geographic disparities that magnify health vulnerabilities among different populations. The review highlights the urgent need for interdisciplinary strategies involving medicine, technology, and public health policy to mitigate the growing burden of climate related disorders. By fostering climate resilient healthcare frameworks, the study aims to guide future scientific and policy initiatives for global health sustainability.*
Keywords: *Climate change; Cardiopulmonary diseases; Thermoregulatory diseases; Environmental health; Global health sustainability*

1. INTRODUCTION

With the rapid urbanization and industrial growth that began in the nineteenth century, human civilization has witnessed remarkable technological and infrastructural progress, but at a tremendous environmental cost [1]. Over the past century, climate change has gradually evolved from being a subtle, localized concern into one of the most pressing global crises of the modern twenty-first century. The consistent rise in greenhouse gas emissions, deforestation, unregulated industrial activities, and large-scale urban expansion have collectively destabilized the delicate equilibrium of the ecosystems of the Earth. The continuous escalation in average global temperatures, rising sea levels, erratic precipitation, and the increasing frequency of extreme weather events are now evident in almost every corner of the world. These environmental transformations are not only altering the physical and ecological systems of the planet but are also deeply influencing human health, particularly in urban populations that are exposed to multiple risk factors simultaneously. Climate change has become a silent but persistent contributor to the spread and intensification of various diseases, reshaping the global burden of illness in ways that were once unimaginable. Health issues such as vector-borne infections, respiratory complications [2], cardiovascular disorders [2], and thermal stress [3] have seen a remarkable surge in recent decades, largely due to environmental disruptions. For example, prolonged heat waves in Europe, South Asia, and North America have led to record-breaking hospital admissions for heat stroke, dehydration, and cardiovascular failures. Similarly, recurrent episodes of poor air quality, as seen in metropolitan areas such as Delhi, Beijing, and Los Angeles, are aggravating respiratory conditions like asthma and chronic obstructive pulmonary disease. The physiological limits of human adaptation are being tested as the world experiences temperature extremes, inconsistent rainfall, and an increasing number of natural disasters, including hurricanes, floods, and wildfires. These multifaceted stressors not only challenge the physical well-being of individuals but also strain the healthcare systems of both developed and developing nations.

The burden of climate-induced diseases is especially profound among the elderly and middle-aged population [1], who exhibit reduced physiological resilience and higher vulnerability to environmental stressors. Studies have demonstrated that prolonged exposure to fluctuating temperatures directly influences cardiovascular regulation and pulmonary function, leading to an alarming rise in deaths related to strokes, heart attacks, and respiratory insufficiencies. The increasing frequency of heat waves in regions such as Southern Europe, Australia, and parts of India has been associated with elevated cases of heat exhaustion and heatstroke, while severe cold waves in Northern Europe and North America have been linked to hypothermia and increased cardiac mortality. The link between climate variability and cardiopulmonary diseases extends beyond temperature fluctuations to include air pollution, pollen distribution, and humidity shifts. For instance, elevated concentrations of particulate matter and ozone during warmer seasons exacerbate chronic lung conditions, while higher pollen counts in extended spring periods intensify allergic respiratory disorders. Moreover, the combined effect of urban heat islands and poor air circulation within densely populated cities further compounds these health threats. The growing incidence of hypertension, ischemic heart disease, and cerebrovascular accidents in recent years illustrates the compounding effect of environmental stressors on cardiovascular health. Beyond the immediate physical consequences, climate-related diseases are also responsible for long-term disabilities, diminished quality of life, and increased healthcare costs, creating an overwhelming global economic and social burden. To effectively address this escalating challenge, it is essential to establish a comprehensive understanding of how geographical, environmental, and socioeconomic factors intersect to influence the prevalence and progression of cardiopulmonary and thermoregulatory diseases. This review therefore aims to delineate the intricate connection between climate change and the increasing global burden of such disorders. It also explores potential pathways for mitigation and adaptation, emphasizing the urgent need for interdisciplinary research that integrates environmental science, medicine, and public health policy to safeguard future generations from the growing health consequences of a rapidly changing climate.

2. INTRODUCTION TO CARDIOPULMONARY DISEASES

2.1. Defining Cardiopulmonary Disease

Cardiopulmonary disease refers to a broad spectrum of disorders that involve the heart, lungs, and associated vascular and neurological systems, reflecting the intricate interdependence of these organs in maintaining oxygen transport and circulation [5, 6]. This group of diseases encompasses various cardiovascular and pulmonary abnormalities that significantly affect the structure and function of the heart, arteries, veins, and respiratory passages. The cardiovascular components include conditions such as high blood pressure (hypertension) and low blood pressure (hypotension) [7], coronary artery disease (CAD) [8], myocardial infarction, arrhythmias, and heart failure [9]. On the pulmonary side, diseases like asthma, chronic obstructive pulmonary disease (COPD), interstitial lung disease, and pulmonary hypertension [6] are frequently observed. Each of these disorders disrupts the normal exchange of oxygen and carbon dioxide, leading to insufficient oxygen supply to vital organs and tissues. For example, COPD and pulmonary hypertension can increase the workload on the heart, eventually causing right-sided heart failure, while severe hypertension can damage the arterial walls and impair lung perfusion. Because the cardiovascular and respiratory systems are functionally connected, impairment in one often amplifies dysfunction in the other, creating a vicious cycle of declining cardiac and pulmonary performance that can culminate in life-threatening complications. Figure 1 enlists all types of cardiopulmonary diseases that are induced by climate change causes.

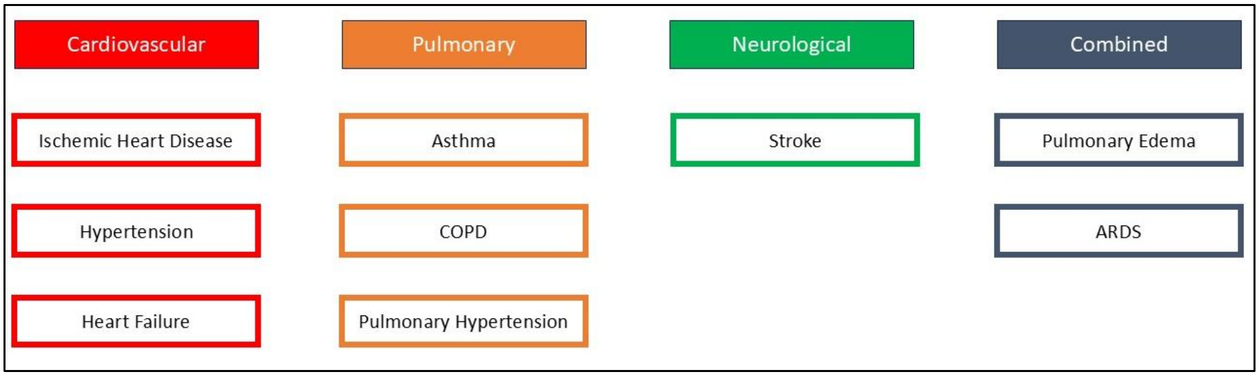

Figure 1. Cardiopulmonary Diseases. This figure enlists all the cardiopulmonary diseases which are induced by climatic changes. These diseases are segregated in four categories, which includes cardiovascular, pulmonary, neurological, and combined.

2.2. Cardiovascular Diseases and Their Relation to Climate Change

2.2.1. Ischemic Heart Disease

Ischemic heart disease develops when the coronary arteries supplying blood to the heart muscles become narrowed or blocked due to atherosclerotic plaque buildup, leading to a reduced oxygen supply to the myocardium [10]. This results in chest pain, shortness of breath, fatigue, and in severe cases, myocardial infarction. Prolonged exposure to extreme temperatures, such as during heat waves, can worsen ischemic symptoms by increasing heart rate and oxygen demand, while dehydration thickens the blood, further reducing circulation efficiency. Additionally, cold environments cause vasoconstriction, elevating blood pressure and triggering cardiac strain. Climate-related stressors, including air pollution and particulate exposure, contribute to endothelial dysfunction and inflammation, accelerating plaque formation. Complications of untreated ischemic heart disease include arrhythmias, heart failure, and sudden cardiac death. The disease not only limits physical endurance and quality of life but also contributes to long-term morbidity, especially among the elderly and those with pre-existing metabolic or vascular conditions.

2.2.2. Hypertension

Hypertension, characterized by persistently elevated arterial pressure of 140/90 mmHg or higher, imposes chronic stress on the cardiovascular system, damaging the endothelium and thickening arterial walls [11]. The condition develops due to genetic, metabolic, and environmental factors, including exposure to heat waves, air pollutants, and noise pollution, all of which trigger stress responses that raise blood pressure. Over time, hypertension increases the risk of serious complications such as stroke, heart failure, kidney disease, and vision impairment. It forces the heart to work harder, eventually leading to left ventricular hypertrophy and reduced cardiac output. During hot weather, excessive sweating and dehydration may disrupt sodium balance, exacerbating hypertensive crises. Uncontrolled hypertension contributes to cognitive decline and vascular dementia due to impaired cerebral perfusion. The global prevalence of hypertension is rising with climate-related stressors and sedentary urban lifestyles, making it a major contributor to cardiovascular mortality and disability worldwide.

2.2.3. Heart Failure

Heart failure arises when the heart becomes unable to pump sufficient blood to meet the metabolic needs of the body, resulting from prior cardiac injury, ischemic disease, or hypertension [12]. Environmental stressors, particularly high ambient temperatures and humidity, can exacerbate symptoms by increasing the heart's workload and causing fluid and electrolyte imbalances. Patients often experience shortness of breath, fatigue, and swelling in the legs or abdomen due to fluid retention. Climate extremes, including heat waves, increase hospitalization rates among heart failure patients because thermal stress leads to vasodilation and reduced blood pressure, which further impairs cardiac output. Cold environments, on the other hand, induce vasoconstriction and raise blood pressure, worsening the heart's workload. Complications include arrhythmias, kidney dysfunction, pulmonary edema, and multi-organ failure in severe cases. Heart failure remains a leading cause of mortality, and its management becomes increasingly complex under the influence of global climate variability and environmental pollution.

2.3. Pulmonary Diseases and Their Relation to Climate Change

2.3.1. Asthma

Asthma is a chronic inflammatory disease of the airways characterized by bronchial hyperresponsiveness, mucus overproduction, and airway constriction [13]. Climate change has intensified asthma triggers, including air pollution, pollen load, and temperature fluctuations. Elevated levels of particulate matter, nitrogen oxides, and ozone exacerbate airway inflammation, while extreme weather events stir up dust, mold spores, and allergens. Common symptoms include wheezing, coughing, and breathlessness, which can progress to life-threatening asthma attacks. Prolonged exposure to environmental pollutants leads to airway remodeling and reduced lung function. Complications include respiratory failure, recurrent infections, and increased susceptibility to chronic obstructive conditions. Children and elderly individuals are particularly at risk due to lower physiological tolerance and compromised immune defense. Climate-induced changes in allergen distribution, especially longer pollen seasons, have further amplified global asthma morbidity, placing a heavy burden on healthcare systems and quality of life for affected populations.

2.3.2. Chronic Obstructive Pulmonary Disease (COPD)

Chronic obstructive pulmonary disease is a progressive lung disorder that restricts airflow and impairs gas exchange, primarily caused by long-term exposure to air pollutants, tobacco smoke, and extreme weather conditions [14]. Climate change intensifies COPD through recurrent exposure to fine particulate matter and rising ozone levels, which aggravate inflammation and oxidative stress in the respiratory tract. The disease manifests with chronic cough, sputum production, and dyspnea that worsen over time. Environmental factors such as cold air and heat waves further narrow airways and reduce oxygenation. Complications of COPD include pulmonary hypertension, right-sided heart failure (cor pulmonale), and acute respiratory failure. During pollution surges or heat stress events, COPD patients face increased hospitalization and mortality risks. The progressive loss of lung elasticity and impaired ventilation severely reduce physical capacity and life expectancy, emphasizing the strong interplay between environmental instability and chronic respiratory decline.

2.3.3. Pulmonary Hypertension

Pulmonary hypertension refers to abnormally elevated blood pressure in the pulmonary arteries, which strains the right ventricle of the heart and impairs oxygen exchange [15]. The condition is frequently associated with chronic exposure to environmental stressors such as high altitude, air pollution, and climate-related hypoxia. Patients experience progressive shortness of breath, dizziness, and chest discomfort. As the disease advances, it can lead to right ventricular hypertrophy and eventual heart failure. Climate-related factors like poor air quality and reduced oxygen concentration contribute to endothelial dysfunction and vascular remodeling, further worsening the condition. Complications include arrhythmias, edema, and life-threatening episodes of syncope or cardiac arrest. Because pulmonary hypertension can result from untreated COPD or recurrent respiratory infections, its prevalence is rising with increasing pollution and global warming. Without early intervention, it leads to severe disability and decreased survival, emphasizing the importance of environmental control in disease prevention.

2.4. Neurological Disorders and Their Relation to Climate Change

Stroke remains one of the most critical neurological outcomes linked to climate change, often triggered by environmental temperature variations, dehydration, and pollution [16]. It occurs when the blood supply of the brain is interrupted due to arterial blockage (ischemic stroke) or vessel rupture (hemorrhagic stroke), resulting in rapid neuronal death and neurological impairment. Heat waves and dehydration increase blood viscosity and thrombosis risk, while cold exposure causes vasoconstriction and elevated blood pressure, predisposing individuals to stroke. Air pollutants and fine particles contribute to vascular inflammation, oxidative stress, and endothelial dysfunction, further heightening stroke risk. Complications include paralysis, speech impairment, cognitive deficits, and, in severe cases, death. Post-stroke survivors often suffer from long-term disabilities, depression, and reduced life expectancy. Climate-induced changes, combined with lifestyle risk factors, have led to a growing global burden of stroke, particularly in vulnerable populations such as the elderly and those with pre-existing cardiovascular disease.

2.5. Combined Cardiovascular Disorders and Their Relation to Climate Change

Combined cardiopulmonary disorders such as pulmonary edema [17] and acute respiratory distress syndrome (ARDS) [18] illustrate the close functional link between the heart and lungs. Pulmonary edema occurs when excess fluid accumulates in the alveoli, often due to left-sided heart failure, which increases pressure in pulmonary veins and capillaries. This condition severely impairs oxygen exchange and can lead to respiratory failure. ARDS, on the other hand, arises from widespread inflammation of the lung tissue, often triggered by infection, trauma, or environmental insults. In both conditions, climate factors such as heat stress, pollution, and hypoxia aggravate disease severity by promoting inflammation and fluid retention. Complications include hypoxemia, multiple organ dysfunction, and in severe cases, death. These disorders exemplify how disturbances in cardiac function can rapidly compromise pulmonary health, emphasizing the importance of addressing environmental and physiological factors together to reduce mortality and disability from interconnected cardiopulmonary diseases.

3. INTRODUCTION TO THERMOREGULATORY DISORDERS

3.1. Defining Thermoregulatory Diseases

Thermoregulatory diseases arise when the body fails to properly regulate its internal temperature in response to environmental changes, leading to an imbalance between heat production and heat loss [19]. The human body maintains its internal temperature within a narrow range of 36.5°C to 37.5°C through physiological mechanisms such as sweating, shivering, and vasodilation or vasoconstriction. When these mechanisms are overwhelmed by extreme environmental conditions, homeostasis is disrupted, and thermoregulatory disorders develop. Prolonged exposure to high temperatures can cause heat-related illnesses such as heat exhaustion, heatstroke, and dehydration. Heatstroke, the most severe form, occurs when the body temperature rises above 40°C, leading to confusion, organ failure, or even death if untreated. Conversely, cold exposure can result in hypothermia, where body temperature drops below 35°C, causing slowed metabolism, confusion, and cardiac arrhythmias. Frostbite, another cold-induced disorder, leads to tissue damage due to freezing of skin and underlying tissues. Climate change, characterized by extreme heat waves and cold spells, has significantly increased the global incidence of these disorders. Elderly individuals, outdoor workers, and those with pre-existing medical conditions are particularly vulnerable. As the frequency and intensity of extreme weather events rise, thermoregulatory diseases have become a major public health concern worldwide [19]. Figure 2 enlists all types of thermoregulatory diseases caused by climate change.

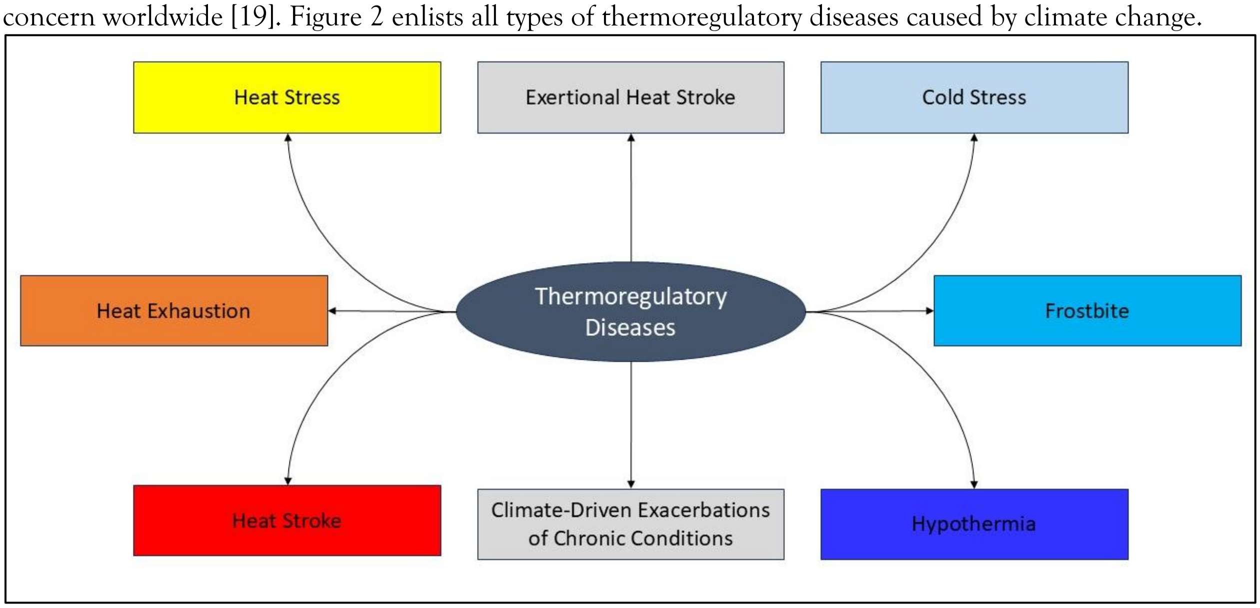

Figure 2. Thermoregulatory Diseases. This figure enlists all types of thermoregulatory diseases which are caused due to climate change. These diseases can be categorized into three categories, that are heat-induced, cold-induced, and extreme-condition-induced.

3.2. Heat-Induced Diseases and Climate Change Relation

3.2.1. Heat Stress

Heat stress occurs when the body's natural cooling mechanisms, such as sweating and blood flow to the skin, are unable to dissipate excess heat efficiently during prolonged exposure to high temperatures [20]. It is a mild but important precursor to more severe heat-related illnesses. Common symptoms include heavy sweating, tiredness, dehydration, muscle cramps, and mild confusion. This condition is often seen among outdoor workers, athletes, and the elderly during heatwaves or in environments with poor ventilation. Prolonged heat stress can impair cardiovascular and thermoregulatory systems, leading to dehydration and electrolyte imbalance. If not managed properly, it can progress into heat exhaustion or heatstroke. Preventive measures include staying hydrated, avoiding physical exertion during extreme heat, and maintaining cool surroundings. Heat stress reflects the initial warning of the body that internal temperature regulation is being challenged by environmental extremes.

3.2.2. Heat Exhaustion

Heat exhaustion represents a more advanced stage of heat-related illness that develops when the body loses excessive water and salt through sweating, leading to dehydration and reduced blood volume [21]. It often manifests as weakness, dizziness, nausea, rapid heartbeat, and profuse sweating. The affected person may also experience muscle cramps and fainting spells due to reduced blood flow to the brain. Heat exhaustion usually arises during intense physical activity in hot and humid environments, especially when individuals fail to replenish fluids adequately. Without prompt treatment, this condition can escalate to life-threatening heatstroke. Immediate management includes moving the patient to a cool environment, resting, and providing oral or intravenous fluids. Elderly individuals, outdoor laborers, and people with cardiovascular diseases are particularly vulnerable. Heat exhaustion serves as a critical warning sign that the thermoregulation of the body is failing under excessive environmental stress.

3.2.3. Heat Stroke

Heatstroke is the most severe and life-threatening form of heat-induced illness, occurring when the body's core temperature exceeds 40°C and fails to cool down naturally [22]. It results from prolonged exposure to extreme heat or strenuous activity in hot environments. Common symptoms include confusion, seizures, lack of sweating despite high temperature, rapid pulse, and loss of consciousness. The condition can lead to widespread organ dysfunction, including damage to the brain, liver, kidneys, and muscles. Immediate medical attention is crucial, as untreated heatstroke can rapidly progress to coma or death. Populations at greatest risk include outdoor workers, elderly individuals, and athletes engaged in high-intensity activities during heatwaves. Climate change, with its rising frequency of extreme heat events, has made heatstroke a growing global health emergency. Rapid cooling methods, such as ice baths and cold IV fluids, are vital in preventing fatal complications.

3.3. Cold-Induced Diseases and Climate Change Relation

3.3.1. Cold Stress

Cold stress occurs when the body experiences prolonged exposure to low temperatures, leading to excessive heat loss and increased strain on the cardiovascular and respiratory systems [23]. It forces the body to work harder to maintain core temperature, triggering vasoconstriction and increased heart rate. Individuals with pre-existing cardiovascular or respiratory diseases face greater risks, as cold exposure can elevate blood pressure and constrict airways, aggravating underlying conditions. Symptoms include shivering, numbness, fatigue, and breathing difficulties. Prolonged cold stress can lead to hypothermia or frostbite if exposure continues. Outdoor workers, homeless individuals, and those without adequate clothing or shelter are particularly vulnerable. Cold stress not only compromises physical health but also affects mental alertness, increasing the risk of accidents and fatigue-related injuries. Preventive measures include proper insulation, layered clothing, and minimizing time spent in freezing environments.

3.3.2. Frostbite

Frostbite is a severe cold-induced injury that results from the freezing of skin and underlying tissues after extended exposure to subfreezing temperatures [24]. It most commonly affects extremities such as fingers, toes, nose, and ears, where blood circulation is naturally reduced. The freezing process leads to the formation of ice crystals in tissues, causing cell damage and restricted blood flow. Early symptoms include numbness, tingling, and pale or hard skin, progressing to blisters and tissue necrosis in advanced cases. Frostbite can lead to long-term complications such as chronic pain, sensitivity to cold, and even amputation in severe instances. Individuals exposed to extreme cold without proper protective clothing, such as mountaineers, soldiers, and outdoor workers, are at highest risk. Preventing frostbite requires adequate insulation, avoiding wet clothing, and limiting exposure to freezing conditions.

3.3.3. Hypothermia

Hypothermia occurs when the body loses heat faster than it can produce, causing the core temperature to drop below 35°C [25]. The condition results in a slowing of metabolic processes and impaired physiological functions. Early signs include shivering, slurred speech, confusion, and extreme fatigue. As the condition worsens, shivering stops, and the heart rate, breathing rate, and blood pressure decrease, potentially leading to unconsciousness and cardiac arrest. Hypothermia is particularly dangerous in wet, windy, or cold environments, especially for the elderly, homeless individuals, and those under the influence of alcohol. Severe hypothermia can result in organ failure and death if not treated promptly. Treatment involves gradual rewarming, dry clothing, and medical supervision. Preventive strategies include layered clothing, proper shelter, and maintaining nutrition and hydration during cold exposure. Hypothermia highlights the body's limited tolerance to prolonged thermal imbalance.

3.4. Other Thermoregulatory Diseases and Connection to Climate Change

3.4.1. Exertional Heat Stroke

Exertional heatstroke is a critical condition that occurs when intense physical activity coincides with high environmental temperatures, overwhelming the ability of the body to dissipate heat [26]. It is most frequently observed among outdoor workers, soldiers, and athletes engaged in strenuous exercise without adequate hydration or rest. The body temperature rises rapidly, often exceeding 40°C, leading to disorientation, collapse, and potential organ failure. Unlike classic heatstroke, exertional heatstroke can affect even young and healthy individuals. Complications include rhabdomyolysis, acute kidney injury, and liver dysfunction. Without immediate medical care, the condition can be fatal. Preventive approaches include acclimatization to heat, maintaining hydration, wearing breathable clothing, and scheduling activities during cooler hours of the day. As global temperatures continue to rise, the incidence of exertional heatstroke is expected to increase significantly, especially in regions with intense outdoor labor and athletic activities.

3.4.2. Climate-Driven Exacerbations of Chronic Conditions

Extreme temperature variations associated with climate change can aggravate pre-existing chronic diseases such as cardiovascular disorders, asthma, and COPD [27]. Heatwaves increase cardiac workload by elevating heart rate and dehydration, while cold spells induce vasoconstriction, raising blood pressure and risk of cardiac events. Similarly, respiratory conditions worsen during heat and pollution peaks, leading to more hospitalizations for asthma and COPD exacerbations. Climate-induced thermal stress can also destabilize metabolic regulation, aggravating diabetes and kidney disease. Elderly individuals and those with limited adaptive capacity face the highest risk of morbidity and mortality during temperature extremes. Complications include arrhythmias, respiratory failure, and acute decompensation of chronic illnesses. These climate-driven exacerbations underscore the growing intersection between environmental instability and public health. Strengthening preventive healthcare, early warning systems, and community adaptation strategies has become essential to mitigate the rising burden of thermally exacerbated chronic conditions.

4. Impact of Climate Change on Cardiopulmonary and Thermoregulatory Diseases

4.1. Current Context of Global Warming

The rise in the temperature of the earth is attributed to various anthropogenic activities, including urbanization, deforestation, rapid industrialization in urban areas, and the emission of greenhouse gases such as carbon dioxide, methane, and synthetic fluorinated gases. These factors contribute to rapid and abrupt climatic changes that significantly impact species on a large scale [28]. Phenomena such as heatwaves and hurricanes, once rare, have become increasingly frequent; these events often lead to rapid temperature fluctuations and unpredictable weather calamities, such as tsunamis, floods, droughts, and forest fires, which occur with greater frequency globally, exerting a substantial impact on life, agriculture, and human health [1].

The increase in global temperature also affects marine life, as rising sea levels induce various changes in marine ecosystems and disasters such as tsunamis, which cause significant shifts in marine biodiversity and disrupt marine ecosystems [29]. The swift consequences of weather changes affect populations globally, although regional variations exist in their impact. Global warming poses a risk to populations worldwide, significantly affecting health on a broad scale, as it is linked to increased cardiovascular diseases, food and water insecurity, and mental health challenges [30]. Given the health-related repercussions and their global impact, various committees are endeavoring to mitigate environmental challenges by reducing greenhouse gas emissions and promoting policies and legislation to lessen their impact. In the future, there is a likelihood of a more rapid increase in temperature. It is imperative to understand and develop strategies and implement policies aimed at improving climate conditions and reducing pollution. As the likelihood of an increase in the global temperature persists, it is crucial to comprehend the health-related consequences and devise strategies to reduce pollution and enhance human health [31, 32].

4.2. Respiratory Challenges in Evolving Climate and Cardiopulmonary Disease Trends

Over recent centuries, there has been an increase in the incidence of diseases such as cardiopulmonary disorders, which impact vital organs like the heart and lungs and are responsible for conditions such as myocardial infarction [5], acute pulmonary disorders [6], and respiratory ailments [33], ultimately leading to mortality. Various risk factors associated with these diseases include rapid fluctuations in weather and temperature, as well as poor air quality; these temperature variations are now more frequent across different continents, thereby affecting the global population. The extreme rise in pollution in urban areas, primarily due to industrialization, has adversely affected air quality, as evidenced by the presence of fine particles and emissions such as harmful gases and particulates, which significantly elevate the risk of respiratory and cardiovascular diseases among individuals [31]. Various cardiovascular diseases, including asthma, chronic obstructive pulmonary disorder, cerebral diseases [5, 6, 33], and thermal illnesses like heat stroke [34], are not solely caused by individual habits such as smoking and dietary practices but are also consequences of increased temperatures and sudden climatic changes, which affect air quality and serve as risk factors for these diseases. Children and individuals diagnosed with other chronic conditions are particularly affected by these circumstances. As cardiopulmonary diseases (CVD) rise globally, leading to epidemic conditions, it is crucial to understand the mechanisms and their interconnection with climatic changes and to develop strategies to mitigate the conditions influenced by these climatic changes [35].

4.3. Climate Extremes as an Emerging Epoch of Thermoregulatory Disorders

In a time characterized by extreme temperature fluctuation, the capacity of the human body to sustain homeostasis is increasingly challenged during these weatherly scenarios. Prolonged heatwaves result in the rise of heat-related illnesses, ranging from mild heat stress to severe heat strokes among the population, particularly affecting areas and populations that are not acclimated to elevated temperatures [36]. On the other hand, cold weather events possess significant risks to communities, especially in locales that lack preparedness for harsh winter conditions, leading to a heightening of hypothermia and frostbite across the cold countries [37]. These thermoregulatory conditions highlight a crucial link between climate change and public health, where human adaptability is being tested in unprecedented manners against these scenarios. Current initiatives aimed at mitigating these health issues are shifting focus towards developing climate-resilient health issues are shifting focus towards developing climate resilient health systems, enhancing public awareness, and implementing health policy measures to alleviate the increasing burden on human thermoregulation [34].

5. Climate Change as the Driving Force behind Health Evolution

5.1. Climate Change as A Definition

Climate change refers to the various enduring modifications of the atmospheric-weathers, across different continents, including temperature, precipitation, wind patterns, and various weatherly elements [38]. Although natural cycles have historically contributed to climate fluctuations, the changes are far less than the present damages, primarily attributable to human activities. These include heightening of greenhouse gas emissions from different urban human-activities including industrial processes, deforestation, and the excessive burning of fossil fuels [39]. The consequences of this human impact are evident in the forms of global temperature fluctuations including frequent heat and cold waves across the continents, disrupted ecosystems in both urban and near-urban areas, and the common occurrence of extreme weather catastrophes [40]. Consequently, climate change has emerged as one of the most crucial challenges due to damaging in both environmental integrity and human health in contemporary society [31].

5.2. Recent Trends of Climate Change

Over the past hundred years, the temperature of the Earth has undergone rapid changes since the pre-industrial period, such as the period between 1750–1850. Over the past four centuries, there has been an increase in global temperature by around 1.1 degrees Celsius. The 2010s contributed as the hottest decade on record. Phenomena like global warming have resulted in various natural destructions, such as the melting of glaciers in the Antarctic region, a sudden increase in sea levels, and various weather-related changes like alterations in precipitation and rainfall patterns, changes in wind patterns, affecting flora and fauna of the region, and disrupting the entire biodiversity of the area. With growing industrialization and urbanization in many countries, especially developed and developing ones, there has been an increase in the overall pollution rate, which causes various weather-related catastrophes and directly affects terrestrial life, marine life, ecosystems, and biodiversity across the area [38, 41, 42].

Table 1. This table indicates the prime indicators of climate change with a comparative analysis of the global scenarios of temperature, CO2 concentration, sea level rise, and frequency of heatwaves among the decades of 1970s, 2000s, and 2020s.

Indicator	**1970**	**2000s**	**2020s**
Global Temperature Rise [42]	~0.2℃ above pre-industrial levels	~0.8℃ above pre-industrial levels	~1.1℃ above pre-Industrial levels
CO_2 Concentration (ppm) [42]	~320	~380	~420
Sea Level Rise (cm) [42]	~10	~20	~25
Frequency of Heatwaves [42]	Rare	Moderate	Frequent

5.3. The Effects of Climate Change on Modern Society

The current era is undergoing persistent and multifaceted climate change which is fundamentally reshaping our way of living and interaction with the surrounding environment. As global temperatures continue to rise in either a rapid or a gradual way across the continents, we are witnessing a critical increase in heat related illness and fatalities. Extended and frequent heatwaves, especially in the summer-prone countries, are placing unprecedented strain on healthcare systems, pushing their limits to their edge and exposing the vulnerabilities of populations that are less equipped to cope with such extremities [40].

The rapid growth of urban areas is influencing these challenges day-by-day, as cities are often turned into "Heat Island" regions where temperatures are significantly higher than in surrounding rural areas due to excessive human activities and infrastructure damaging the air-quality of the surrounding environment [43]. These phenomenon is continuously affecting vulnerable groups in the human, including the children and elderly, low-income families, and those with pre-existing health conditions, like hypertension, obesity, and diabetes, who are more susceptible to the adverse effects of extreme heat conditions [44]. In addition to the rising temperatures, we are also facing frequent and severe weatherly disasters, such as hurricanes, floods, and droughts. These events are not only wreaking havoc by damaging the human-made-infrastructures, including homes, buildings, roads, and essential services, but also displacing the affected communities, forcing individuals and families to leave their living places in search of safety and stability [40]. The psychological toll of such displacement can lead to significant mental health struggles, while the disruption of food supply chains can result in acute food shortages, leading to the influencing factors of different cardiopulmonary disease including hypertension, heart attacks, strokes and others [45]. Furthermore, the aftermath of these disasters often leads to the spread of various viral and zoonotic diseases associated with contaminated water and food sources, compounding the public health crisis [35].

The cascading effects of climate change create a complex web of crisis, where our cardiac, pulmonary and neurological health becomes increasingly vulnerable due to the continuous fatal effects on the body. The correlation cycle of climatic influence and health outcomes highlights the urgent need for a comprehensive understanding of how climate change impacts human well-being, mainly in the neurological, cardiological, pulmonary and cardiovascular aspects [5]. From unusual weather patterns that disrupt daily life of ours to the ongoing arising health challenges from these climatic catastrophes, the influence of climate change on our lives and health has become profound and far-reaching, especially since the last three decades [46].

As we navigate this new reality, it is imperative for policymakers, scientists, and everyday citizens to collaborate in developing effective strategies for both mitigation and adaptation against these health effects led by climatic changes. This collective effort is essential not only to address the immediate impacts of these extreme and untimely climatic change but also to build resilience in the future aspect of human health sciences. By fostering a proactive approach that prioritizes sustainability and public health, we can work towards a more equitable and secure world to face the ongoing environmental and climate related health challenges [46, 47].

6. Worldwide Impact of Cardiopulmonary Diseases with Respect to Climate Change

The burden of cardiopulmonary diseases has witnessed an alarming increase worldwide, with climate change emerging as a crucial, though often underestimated, contributing factor. Heart and lung diseases have surged dramatically in both developed and developing nations, largely due to rapid urbanization, industrialization, and the resulting environmental pollution that directly impacts the cardiovascular and respiratory systems. According to the World Health Organization (WHO), cardiovascular diseases are the leading cause of death globally, responsible for nearly 17.9 million deaths each year. Similarly, respiratory disorders, such as chronic obstructive pulmonary disease (COPD), asthma, and other pollution-related pulmonary conditions, account for approximately 3.9 million deaths annually. This pattern underscores the intricate link between environmental degradation and the rise of cardiopulmonary morbidities [48, 49].

Climate change has multifaceted effects on human health. Rising global temperatures, deteriorating air quality, and the increasing frequency of extreme weather events all contribute to the progression and exacerbation of cardiovascular and pulmonary diseases. For instance, countries experiencing prolonged heatwaves and high ambient temperatures, such as parts of Europe, South Africa, and South Asia, report a higher prevalence of cardiovascular and pulmonary complications. Heat exposure places additional strain on the cardiovascular system, as the body must work harder to maintain thermal balance. This stress increases the risk of arrhythmias, heart attacks, and strokes, particularly among elderly individuals and those with pre-existing medical conditions. Moreover, excessive heat exposure can cause dehydration and electrolyte imbalances, further aggravate cardiac load and impair normal heart function [48, 49].

Air pollution acts as one of the strongest mediators linking climate change to cardiopulmonary diseases. Pollutants such as particulate matter (PM2.5 and PM10), nitrogen oxides (NOx), carbon monoxide (CO), sulfur dioxide (SO_2), and ground-level ozone (O_3) are known to trigger oxidative stress and systemic inflammation, leading to endothelial dysfunction, atherosclerosis, and hypertension. Chronic exposure to polluted air also worsens respiratory diseases like asthma and COPD. In many industrialized cities, especially those with poor Air Quality Index (AQI) scores, residents face a dual burden: environmental pollution and elevated ambient temperature, both of which amplify cardiopulmonary risks [48, 49].

Studies have shown a strong correlation between temperature fluctuations and cardiovascular events. Even a modest 1°C rise in temperature has been associated with a 5% increase in cardiovascular conditions such as ischemic heart disease and stroke [50, 51]. Heatwaves, which are becoming more frequent and severe due to global warming, can exacerbate underlying heart and lung conditions, particularly among the elderly and vulnerable populations. Heat-induced stress often leads to elevated heart rate, reduced blood pressure regulation, and increased blood viscosity, all of which heighten the risk of myocardial infarction. Simultaneously, hot and stagnant air conditions can trap pollutants closer to the ground, worsening air quality and further damaging pulmonary health.

On the respiratory front, climate change also contributes to an increase in allergenic and infectious respiratory diseases. Warmer temperatures promote the proliferation of pollen-producing plants and extend pollen seasons, worsening allergic asthma. Similarly, rising humidity and pollution levels facilitate the survival and transmission of airborne pathogens, leading to an uptick in respiratory infections. The compounding effects of heat stress, poor air quality, and increased allergen exposure place an enormous strain on public health systems, especially in regions with limited healthcare infrastructure [50, 51].

Beyond direct health impacts, climate change indirectly affects cardiopulmonary health by influencing socioeconomic and behavioral determinants. Food insecurity, displacement, mental stress, and reduced physical activity due to extreme weather patterns all contribute to worsening cardiovascular and respiratory outcomes. People living in low-income urban settlements, often located near industrial zones or congested traffic areas, face disproportionate exposure to pollutants and higher heat stress levels. As a result, health inequities are magnified, with marginalized communities bearing the greatest burden of disease [50, 51].

The correlation between human health, climate, and biodiversity has become increasingly evident in recent decades. The delicate balance of ecosystems plays a vital role in regulating air quality, temperature, and overall environmental stability. Disruption of these natural systems through deforestation, fossil fuel combustion, and unregulated industrialization not only accelerates climate change but also erodes the natural capacity of the planet to buffer harmful effects on human health. Thus, understanding the link between cardiopulmonary diseases and climate change requires a holistic approach, integrating environmental science, epidemiology, and sustainable public health policies [50, 51].

To mitigate these challenges, comprehensive global and regional strategies must be developed. Policymakers need to implement and enforce emission control measures, promote renewable energy adoption, and improve urban planning to enhance air circulation and reduce heat island effects. On a broader scale, international cooperation under frameworks such as the Paris Agreement must continue to emphasize reducing greenhouse gas emissions. Public awareness campaigns about the health risks of climate change and the importance of sustainable living are equally critical. As emphasized by several global organizations, these "star-gazing" goals and policies should aim to minimize the human-induced environmental damage that fuels the ongoing rise in cardiopulmonary diseases [35].

7. Worldwide Impact of Thermoregulatory Diseases with Respect to Climate Change

The growing frequency and intensity of thermoregulatory disorders reflect one of the most pressing health challenges emerging from global climate change. With the steady and often abrupt increase in global temperatures, human physiological mechanisms for maintaining internal thermal balance are being pushed to their limits. The thermoregulation of the human body depends on a narrow temperature range to sustain vital metabolic functions, and even minor deviations, caused by external environmental extremes, can lead to severe health consequences. The rising prevalence of heat-related and cold-related illnesses worldwide indicates that climate instability is increasingly translating into a direct public health threat [52].

Heatwaves, described as prolonged periods of excessively high temperatures, represent one of the deadliest manifestations of climate change. These "pheromones" of environmental stress, as described, are among the most challenging climate-induced phenomena, capable of triggering a cascade of thermoregulatory failures. Sudden and drastic temperature changes can overwhelm the body's ability to maintain homeostasis, leading to conditions such as heat exhaustion, heat cramps, and heatstroke. The latter, in particular, is a potentially fatal condition characterized by body temperatures exceeding 40°C, central nervous system dysfunction, and multiple organ failure. These heat-related disorders have contributed to significant mortality across continents, particularly during severe heatwave events that have become more frequent and prolonged in recent decades [52].

At the same time, extreme cold events, though less frequent, pose equally severe risks, especially in regions unaccustomed to freezing temperatures. Cold stress leads to vasoconstriction, reduced blood flow, and ultimately hypothermia, where core body temperature falls below 35°C. Such conditions can impair cardiac function, slow metabolic processes, and even lead to death if exposure is prolonged. Cold-induced health problems are particularly prevalent in regions such as Europe, North America, and high-altitude zones, where sudden drops in temperature, snowstorms, and prolonged winter seasons can create life-threatening situations for unprepared populations [53]. The interplay between global warming and erratic cold spells, a paradoxical outcome of disrupted atmospheric circulation patterns, illustrates the unpredictable nature of climate change and its far-reaching implications for human thermoregulation.

Geographical location plays a critical role in determining the type and prevalence of thermoregulatory diseases. Populations residing in hot, arid regions such as Saudi Arabia, sub-Saharan Africa, and parts of South Asia are more susceptible to heat-related illnesses due to high ambient temperatures and limited access to cooling infrastructure [54]. Conversely, individuals living in colder climates, such as Europe, North America, and the Arctic regions, are more prone to hypothermia and frostbite. However, globalization, migration, and rapid urbanization have blurred traditional climatic boundaries, exposing populations worldwide to a wider spectrum of temperature-related risks. Urban areas, in particular, experience intensified heat exposure due to the "urban heat island effect," where concrete structures absorb and retain heat, elevating local temperatures beyond surrounding rural areas. This effect disproportionately impacts low-income communities with poor housing, limited ventilation, and inadequate access to cooling resources.

Socioeconomic vulnerability compounds the burden of thermoregulatory diseases. People lacking sufficient resources, especially those in developing regions, are disproportionately affected by extreme weather events. Inadequate housing, poor insulation, lack of air conditioning or heating systems, and limited access to healthcare infrastructure leave these populations defenseless against the extremes of temperature variation [52]. The elderly, children, and individuals with chronic diseases such as diabetes or cardiovascular conditions face higher risks because their physiological adaptability to temperature stress is reduced. Moreover, outdoor laborers, farmers, and construction workers are directly exposed to environmental extremes, increasing the occupational hazard of thermoregulatory disorders.

Climate models and weather forecasts indicate a continuing upward trend in global temperatures, suggesting that the frequency and severity of thermoregulatory disorders will intensify in the near future. Projections suggest that each decade will likely experience an incremental rise in average temperature, amplifying the potential for heatwaves and altering traditional seasonal patterns. This increase will likely expand the geographic range of heat-related morbidity, pushing diseases once confined to tropical regions into temperate zones. Without timely adaptation strategies, this shift could overwhelm public health systems, particularly in resource-constrained settings [55].

Addressing the growing threat of thermoregulatory diseases demands a multidimensional approach that combines infrastructure improvement, health education, and climate resilience planning. Developing robust early warning systems for extreme heat and cold events, promoting community awareness on preventive measures, and integrating thermal safety into urban design are critical steps. Strengthening healthcare systems to handle climate-induced emergencies and ensuring equitable access to cooling and heating technologies are equally vital. Governments and international bodies must also recognize thermoregulatory health as a central component of climate policy, integrating it with broader environmental and social strategies [55].

Understanding the mechanisms behind thermoregulatory disorders, how environmental extremes disrupt body temperature balance, circulation, and metabolism, can guide more effective interventions. By linking environmental science with medicine and public health, societies can develop targeted strategies to protect vulnerable populations and mitigate the health consequences of global temperature instability. Ultimately, building climate-adaptive infrastructure and prioritizing public health resilience will be essential to counter the escalating burden of thermoregulatory diseases worldwide [55]. Table 2 showcases the burden of thermoregulatory diseases with respect to the effects of climate change.

Table 2. Global burden of thermoregulatory diseases in modern era with respect to the current effects of climate change.

Disease	**Estimated Annual cases**	**Estimated Annual**	**Key Environmental Triggers**
Heat Stress [56]	~75	<1	Heatwaves, prolonged sun exposure
Heatstroke [56]	~2	50	Extreme heat events, high humidity
Hypothermia [57]	~1.5	25	Cold spells, lack of adequate heating

Frostbite [24]	~0.3	Rare	Freezing temperatures, high altitude
Exertional Heatstroke [56]	~1.2	10	Physical activity in high temperatures
Climate-Driven Cardiac Events [58]	~10	100+	Thermal stress exacerbating chronic illness

8. Climate Change Perspective on Cardiopulmonary and Thermoregulatory Burden

8.1. Connecting Health with Climate Change

Various natural climatic calamities, such as heatwaves, sudden drops in temperature across various continents, and phenomena like air pollution, serve as risk factors for various diseases and epidemics that can arise from contaminated water and food. Calamities like these have a great impact on the human biological network, especially affecting the cardiovascular and pulmonary systems, as well as thermoregulatory disorders, which disrupt human health [59] [60]

8.2. Recent Outbreak Trends of Cardiopulmonary and Thermoregulatory Disorders

In the summer of 2003, Europe faced one its most lethal heatwaves, leading more than 70,000 fatalities, predominantly affecting the elderly population . The main contributors to these deaths included dehydration caused by heat, increased strain on the cardiovascular system, and the worsening of respiratory illness [61]. Major urban areas such as Paris and Madrid experienced notable increases in emergency room admissions, highlighting the susceptibility of densely populated regions with inadequate ventilation [62]. South Asia, which contains some of the most polluted urban areas globally has experienced a significant increase in asthma cases, especially among the pediatric population. For instance, Delhi, India, records alarmingly high concentrations of particulate matter (PM2.5), exacerbating respiratory ailments. Factors such as seasonal agricultural burning and escalating temperatures further degrade the air quality in the region, resulting in a persistent health emergency [63]. Extreme cold events continue to pose a considerable health threat, even as heat-related illnesses often take center stage in climate discussions. A notable example is the polar vortex that occurred in the United States in 2014, which led to a rise in cases of hypothermia and cold-related heart attacks, particularly affecting vulnerable groups such as the homeless and the elderly [64]. Japanese elderly population encounters increased dangers during the intense summer heat. A heatwave in 2018 led to numerous hospital admissions due to heatstroke and cardiovascular issues, which prompted the government to allocate resources towards the development of early warning systems for heatwaves [65]. Countries such as Fiji and the Maldives are confronted with two significant challenges, namely increasing sea levels and severe weather events [66] [67]. The occurrence of frequent cyclones hampers access to healthcare [68], exacerbates respiratory issues linked to waterborne illnesses [69], and subject communities to heightened heat stress [70].

8.3. Discussion on Climate Change Induced Global Burden of Cardiopulmonary and Thermoregulatory Diseases

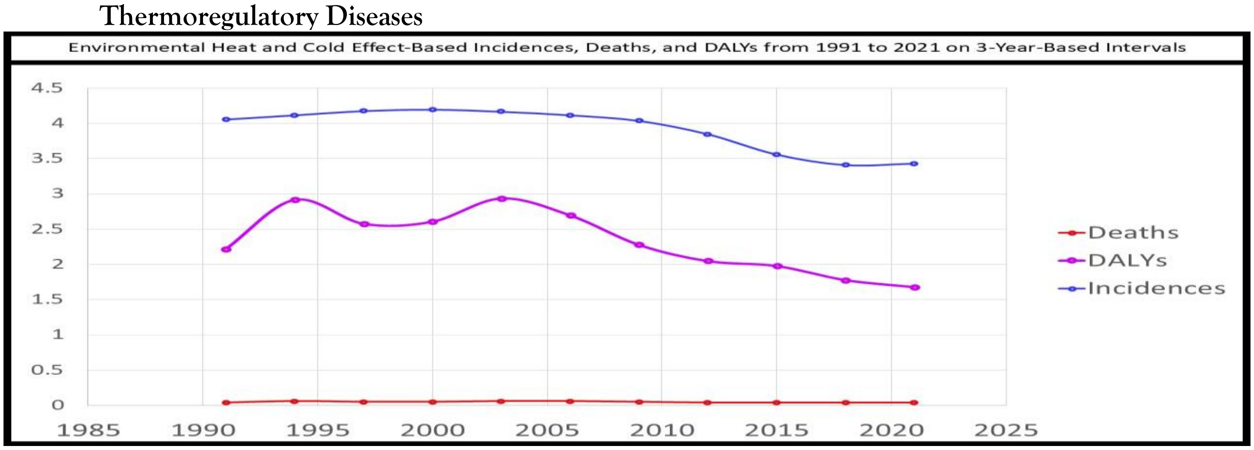

Figure 3. Global Burden of Environmental Heat- and Cold-Related Effects Graphical Representation. This figure visualizes the progression of environmental heat- and cold-related exposure incidences, DALYs, and deaths [72] [73].

Since the 2010s, the progression of cardiopulmonary and thermoregulatory disorders has significantly increased over time, with environmental imbalance, local weather pattern alterations, and climate change identified as major contributors to this phenomenon. In short, despite improvements in cure rates, the number of individuals affected by these disorders remains high and is continuously growing, while death and disability cases continue to be a major concern. Although developed countries are showing stable annual progression rates of these diseases, developing and underdeveloped countries have become epicenters, with significantly concerning rates of progression. The occurrences of stroke, ischemic heart disease, and heart failure have continued to follow the same progressive trend observed since the 1990s. In this context, although asthma occurrences showed a decrease from the 1990s to the 2000s, since the 2010s, the cases have been rising, with air pollution and climate change emerging as major contributors. In contrast, cold-related illnesses are on the verge of decreasing due to the modernization of weather forecasting technologies and the widespread availability of air-conditioning and heating systems. Although there has been a decrease in cold-related illness rates, heat-related illnesses, along with their associated disabilities and mortalities, are becoming more prominent. With constantly changing climate patterns and random fluctuations in local weather, the incidences of COPD and other pulmonary diseases are increasing substantially, contributing significantly to the global mortality burden [71] [72] [73]. Figures 1–5 show global trends in main health burdens from 1991 to 2021. Figure 3 depicts trends in heat and cold-related diseases, including impacted cases, fatalities, and DALYs. Figures 4 and 5 depict stroke and ischemic heart disease trends, respectively, with gender-based distributions, pie charts of outcomes (deaths, DALYs, cures) across 10-year intervals, and age-based demographics for 2021. Figure 6 depicts changes in asthma incidence, DALYs, and fatalities, as well as gender and age-based statistics for 2021. Figure 7 depicts COPD trends, including gender and age breakdowns and a sunburst graphic of results.

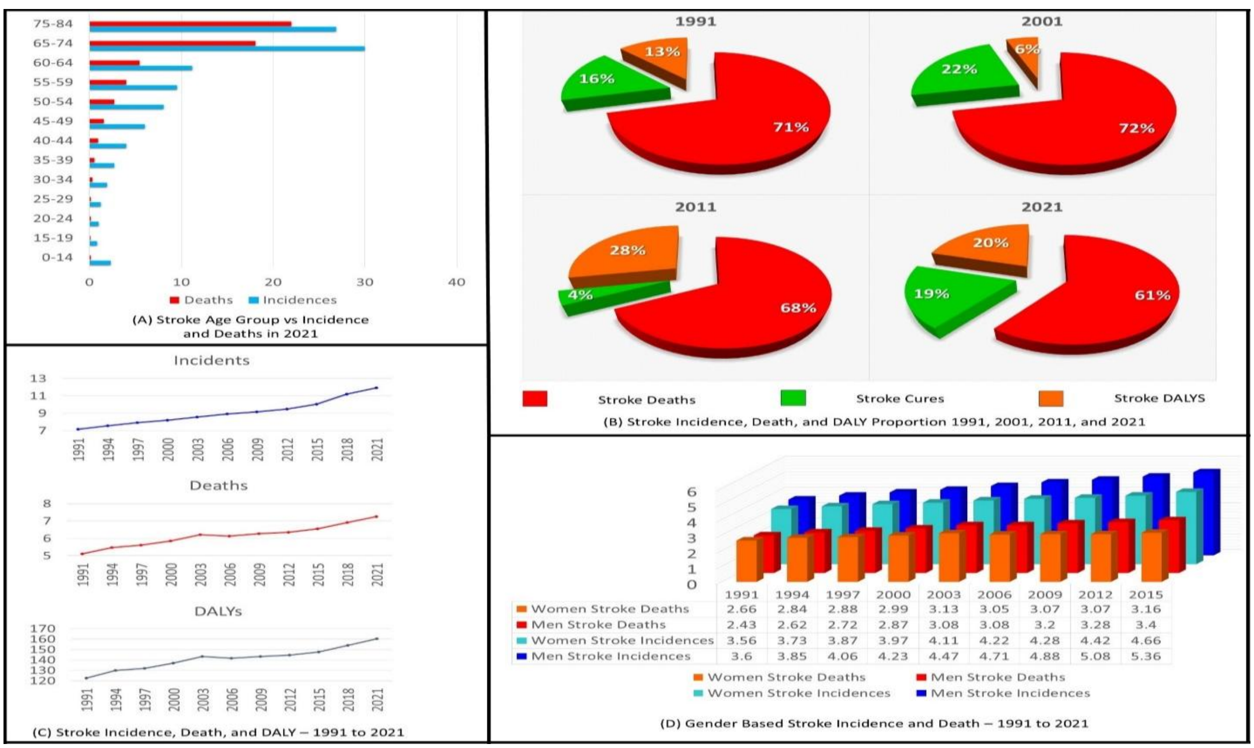

Figure 4. Stroke Global Burden Graphical Representation. (A) represents the age-based demographic representation of stroke in 2021 (1 unit at Y-axis = 100,000). (B) visualizes the pie-chart-based distribution of deaths, DALYs, and cures among total incidences of 1991, 2001, 2011, and 2021. (C) shows the progression of incidences, deaths, and DALYs of stroke from 1991 to 2021 on 3-year-based intervals (1 unit at Y-axis = 1 million). (D) demonstrates the gender-based distribution of incidences and deaths from 1991 to 2021 on 3-year-based intervals (1 unit at Y-axis = 1 million) [72] [73]

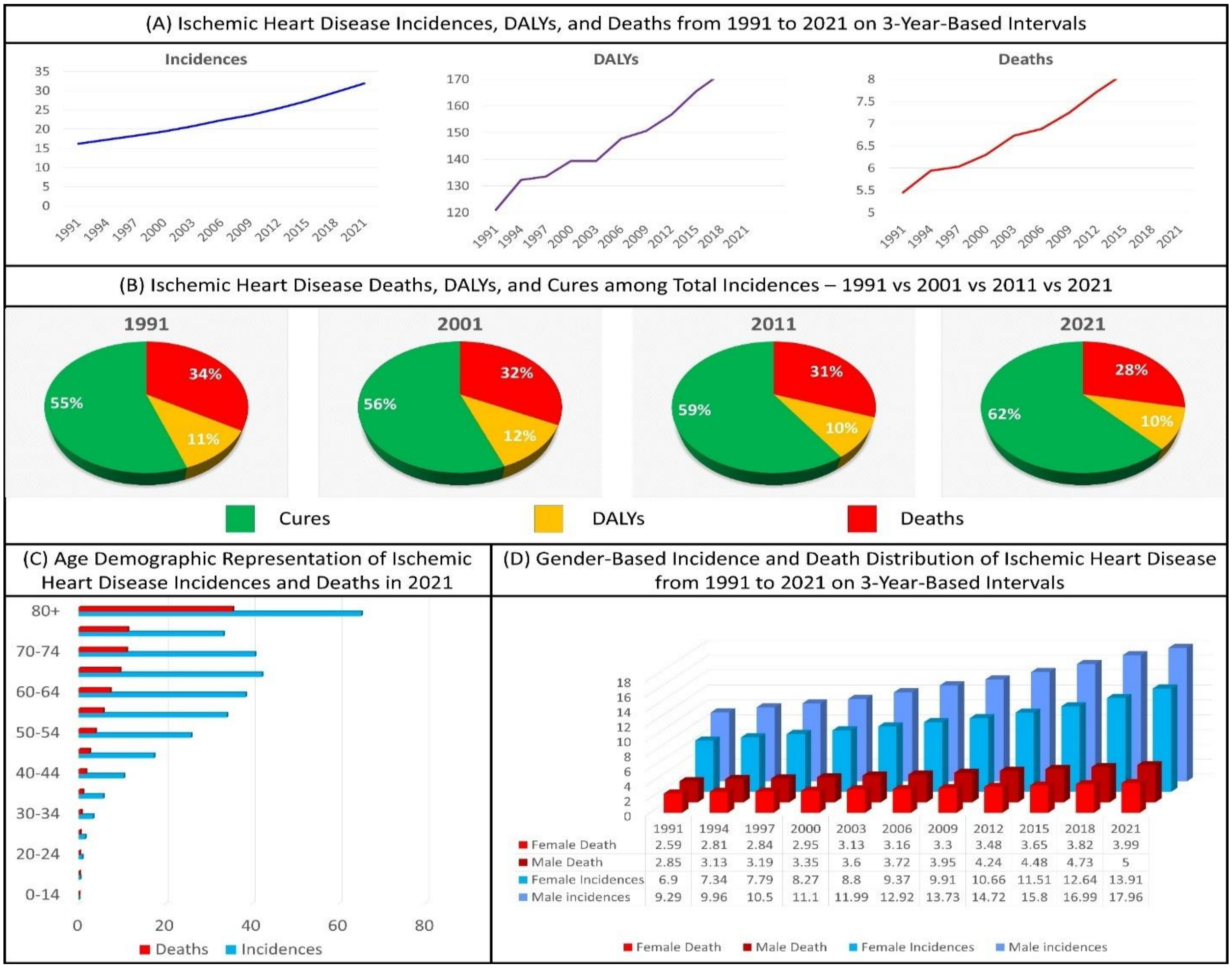

Figure 5. Ischemic Heart Disease Global Burden Graphical Representation. (A) shows the progression of incidences, deaths, and DALYs of ischemic heart disease from 1991 to 2021 on 3-year-based intervals (1 unit at Y-axis = 1 million). (B) visualizes the pie-chart-based distribution of deaths, DALYs, and cures among total incidences of ischemic heart disease of 1991, 2001, 2011, and 2021. (C) represents the age-based demographic representation of ischemic heart disease in 2021 (1 unit at Y-axis = 100,000). (D) demonstrates the gender-based distribution of incidences and deaths of ischemic heart disease from 1991 to 2021 on 3-year-based intervals (1 unit at Y-axis = 1 million) [72] [73].

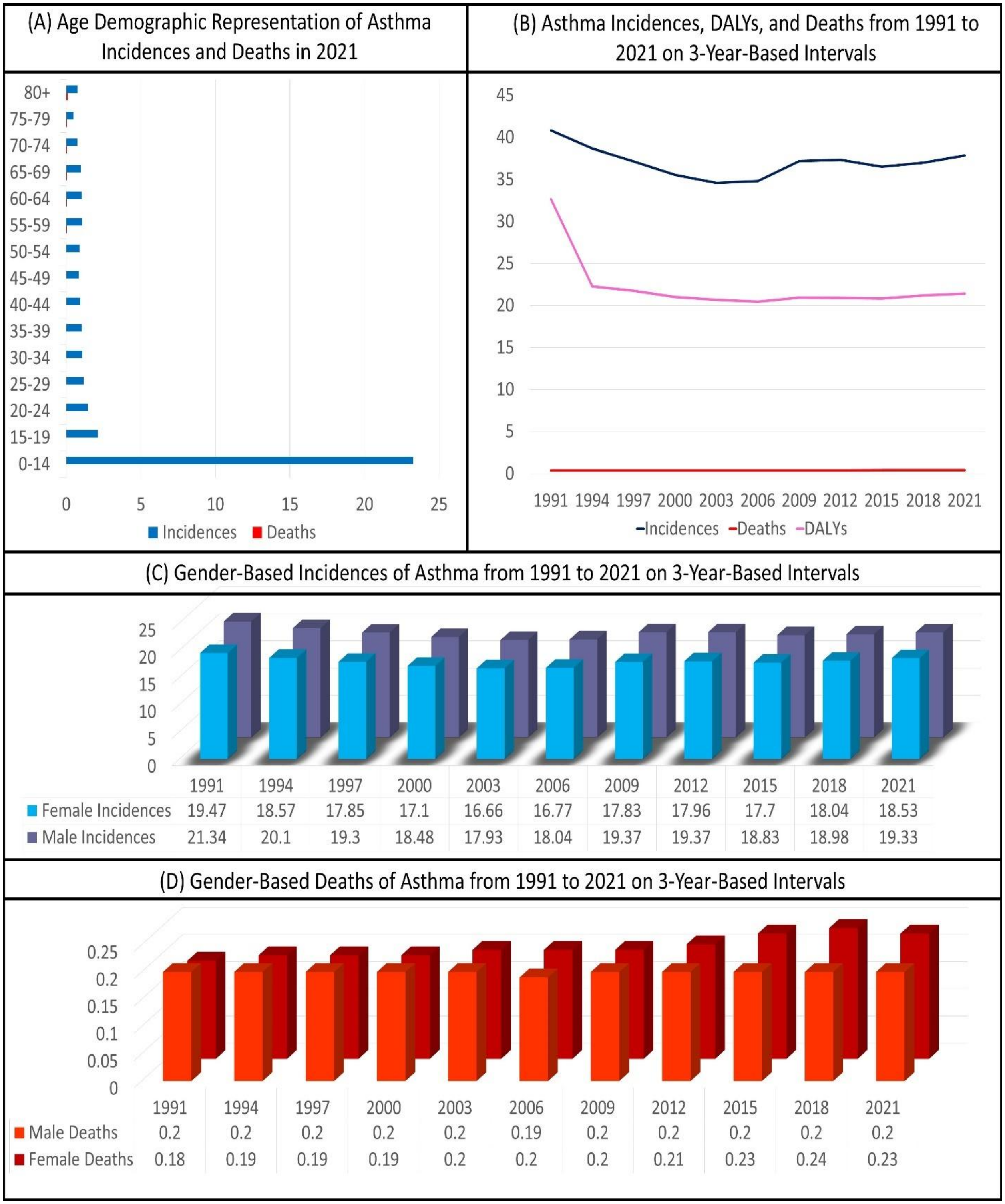

Figure 6. Asthma Global Burden Graphical Scenario. (A) represents the age-based demographic representation of asthma in 2021 (1 unit at Y-axis = 1,000,000). (B) shows the progression of incidences, deaths, and DALYs of asthma from 1991 to 2021 on 3-year-based intervals (1 unit at Y-axis = 1 million). (C) demonstrates the gender-based distribution of incidences asthma from 1991 to 2021 on 3-year-based intervals (1 unit at Y-axis = 1 million). (D) demonstrates the gender-based distribution of deaths of asthma from 1991 to 2021 on 3-year-based intervals (1 unit at Y-axis = 1 million) [72] [73].

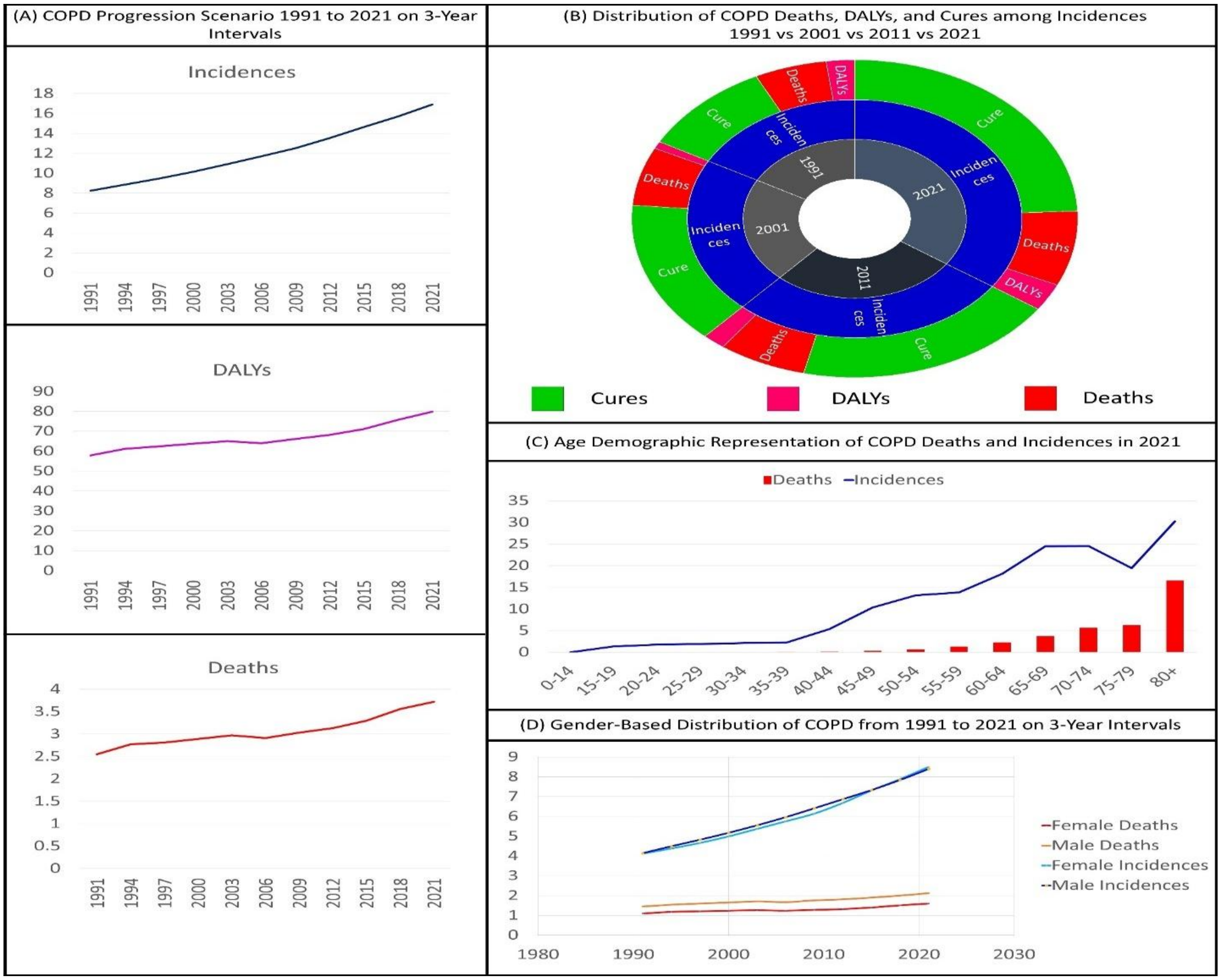

Figure 7. COPD Global Burden Graphical Representation. (A) shows the progression of incidences, deaths, and DALYs of COPD from 1991 to 2021 on 3-year-based intervals (1 unit at Y-axis = 1 million). (B) visualizes the sunburst-chart-based distribution of deaths, DALYs, and cures among total incidences of COPD of 1991, 2001, 2011, and 2021. (C) represents the age-based demographic representation of COPD in 2021 (1 unit at Y-axis = 100,000). (D) demonstrates the gender-based distribution of incidences and deaths of COPD from 1991 to 2021 on 3-year-based intervals (1 unit at Y-axis = 1 million) [72] [73].

9. Future Perspective of Cardiopulmonary and Thermoregulatory Diseases in Light of Climate Change

With the rise in the global temperature of Earth and drastic changes in weather patterns, public health has undergone significant changes. With respect to diseases like thermoregulatory diseases and cardiopulmonary diseases, both together are contributing factors to mortality on a global scale and are now significantly triggered by sudden climatic changes. They are expected to increase in severity and mortality due to the drastic impact of sudden climatic changes on the global population [74].

In the upcoming centuries, extreme temperature differences, like prolonged heat waves and sudden cold spells, are expected to be more intense and sudden, which can lead to physiological stress on the global population, especially among those prone to heatwaves and cold spells. This can lead to fatal conditions, like heatstroke and cardiovascular collapse, and an increase in pre-existing respiratory conditions like asthma. Vulnerable populations will be drastically affected by these conditions as they lack basic access to heating and cooling systems [74] [75].

At the same time, the Air Quality Index (AQI) is going to be affected drastically due to the sudden rise in temperature and rapid industrialization. An increase in the level of ground ozone, exposure to pollen particles, and an increase in the number of suspended particles like PM2.5 and PM10 will trigger an inflammatory response in individuals, which will directly affect the cardiovascular and respiratory systems. Without technological intervention to control pollutants in urban areas and due to the lack of a monitoring system, a large population, especially in urban contexts, will be affected by diseases like COPD, asthma, ischemic heart disease, and stroke [76].

Simulations suggest a probability of widespread vector-borne diseases in previously unaffected regions, which can expose new populations to infections, affecting their heart and lungs. Diseases spread through contamination, like dengue and malaria, once present in tropical regions of Earth, can spread even to temperate regions due to the expansion of vectors like the Aedes mosquito. The chronic response to these diseases can also lead to chronic cardiopulmonary disease conditions [77].

However, socio-economic conditions and challenges, including displacement, food scarcity, and degrading healthcare services, will only worsen mental health conditions and trigger harmful acclimation by humans to these changes, such as increased cases of tobacco and alcohol consumption and reduced access to healthcare systems. This will trigger cardiopulmonary responses and further lead to chronic diseases, especially in hostile regions [78].

Considering the infrastructure and policies, making an integrated and quick response has become mandatory to mitigate the risk of disease. The healthcare system should be more robust to climate change and resilient in responding to sudden changes [60]. Reducing the risk of disease may include the following. Firstly, Early warning systems for climate changes and increased surveillance for monitoring the Air Quality Index, assessing extreme temperature changes, and predicting disease outcomes. Secondly, Use of green technology and investment in cooling centers, and promoting vehicles that emit fewer harmful gases, thus improving the transportation sector. Moreover, Organization of public health camps to raise awareness and emphasize the reduction of environmental stressors or inflammatory agents. Also, Development of emergency response systems in vulnerable regions.

Additionally, international cooperation is necessary to reduce the impact of climate change across borders. Funding for research to mitigate the risk of climate change and constructing climate-adaptive infrastructure, as well as ensuring access to healthcare equipment, must be considered a top priority through global healthcare frameworks such as WHO Climate and Health Country Profiles and the Sustainable Development Goals set by the UN [79].

In conclusion, the integration of climate change with diseases like thermoregulatory and cardiopulmonary conditions presents a global public health challenge. Science-driven strategies and public health awareness are necessary to prevent illness and death in the global population. There is a crucial need to transform and frame effective policies and improve healthcare systems to reduce health risks due to sudden climate change.

10.Future Research Scopes

Future research on the intersection of climate change and human health offers vast and urgent potential. As global temperatures continue to rise, understanding how environmental instability drives disease dynamics remains a scientific and societal priority. Future investigations must expand beyond correlational studies to unravel mechanistic pathways linking climatic stressors with biological responses. Longitudinal and multi-regional datasets can help identify how temperature fluctuations, air pollutants, and humidity patterns influence cardiovascular and respiratory physiology over time. The development of predictive models integrating climatic variables with epidemiological data could enable early warnings for disease outbreaks or heat-related emergencies. Furthermore, genomic and molecular-level research is needed to uncover how repeated exposure to environmental stress alters cellular signaling, inflammation, and oxidative balance, pathways central to cardiopulmonary and thermoregulatory disorders.

An emerging focus of future studies should be on the use of artificial intelligence and machine learning for real-time health monitoring and prediction. AI-driven wearable technologies could track vital parameters such as heart rate variability, oxygen saturation, and body temperature to assess physiological resilience during heatwaves or cold spells. Integrating such data into climate-health dashboards could help predict health crises before they occur, facilitating preventive interventions at both individual and population scales. Similarly, digital twins, virtual simulations of human physiological responses under varying environmental conditions, could offer new avenues for risk modeling. Future research could also aim to refine these systems through personalized algorithms that adapt to demographic and genetic variability, providing a precision-medicine framework within environmental health science.

At the public health policy level, interdisciplinary research will be vital for translating scientific evidence into actionable strategies. Collaborative frameworks involving climate scientists, physicians, urban planners, and policymakers could guide the design of climate-resilient cities that mitigate the heat-island effect and improve air quality. Large-scale epidemiological studies should investigate socioeconomic determinants, such as housing, occupation, and access to healthcare, that amplify vulnerability to climate-related diseases. Evaluating the cost-effectiveness of community-based interventions, such as cooling centers and air-quality alert systems, can provide governments with data-driven guidance for resource allocation. Additionally, studying the indirect impacts of climate change, such as food insecurity, displacement, and mental health deterioration, will help construct a more comprehensive view of planetary health.

Finally, there lies an urgent research gap in adaptive physiology and therapeutic innovation. Experimental studies exploring pharmacological or nutritional agents that enhance thermoregulatory efficiency or reduce oxidative stress under extreme conditions could revolutionize climate medicine. Investigating the long-term adaptation of human systems to altered environmental baselines, especially among populations chronically exposed to heat or pollution, may reveal new insights into resilience mechanisms. Future research must also focus on education and awareness, examining how behavioral and cultural factors shape adaptation to changing climates. In essence, the coming decades will demand a seamless fusion of biomedical science, environmental analytics, and social innovation to safeguard human health against a rapidly shifting planet. The challenge is immense, but so is the scientific opportunity to redefine global health for a warming world.

11.Novelty of the Review

The novelty of this paper lies in its integrative approach to connecting climate change with cardiopulmonary and thermoregulatory diseases through a unified analytical framework. Unlike traditional studies that examine these conditions in isolation, the paper synthesizes environmental, physiological, and epidemiological dimensions to demonstrate how temperature fluctuations, air pollution, and climatic variability jointly influence human health. This multidimensional linkage offers a fresh perspective on understanding disease causation beyond conventional biomedical factors, emphasizing climate as a primary physiological stressor.

Another distinctive aspect is the inclusion of the paper of thermoregulatory disorders alongside cardiopulmonary conditions, which is an area rarely explored in tandem. By highlighting how both heat and cold extremes disrupt homeostasis and trigger systemic cardiovascular and respiratory responses, it expands the current scientific discourse on climate-induced health impacts.

Furthermore, the forward-looking discussion of the paper on technological integration, such as predictive modeling, early warning systems, and adaptive healthcare strategies, adds a contemporary and solution-driven edge to the topic. Its synthesis of global case studies, quantitative data, and policy insights creates a framework that is not only descriptive but also predictive. Collectively, the novelty of the paper stems from its interdisciplinary scope, mechanistic depth, and vision for merging environmental and clinical research into a cohesive, climate-responsive health paradigm.

12.Strengths of the Review

The paper demonstrates several notable strengths that contribute to its academic and practical significance. First, it presents a comprehensive and multidisciplinary examination of the relationship between climate change and human health, particularly emphasizing cardiopulmonary and thermoregulatory disorders. By integrating perspectives from environmental science, epidemiology, and medicine, the work successfully bridges the gap between clinical research and global climate studies, offering a holistic understanding of how environmental factors influence physiological systems.

Another key strength lies in its detailed organization and clear narrative flow. Each section systematically progresses from defining disease mechanisms to explaining their environmental triggers and then linking

them with global climatic trends. This structured approach enhances readability while maintaining scientific rigor. The inclusion of real-world examples, such as heatwaves in Europe, cold stress in North America, and pollution crises in Asia, further grounds the discussion in practical context, enabling readers to connect theoretical concepts with current global realities.
The extensive literature base and citation network also reinforce the credibility of the paper. References to recent studies, WHO reports, and data from global burden analyses strengthen the evidence supporting each argument. The visual representations of the paper, such as figures and tables illustrating disease burdens and climatic indicators, provide clarity and make complex datasets accessible for interpretation.
Importantly, the future-oriented perspective of the review sets it apart. It not only analyzes the current scenario but also anticipates how evolving climate dynamics may reshape disease prevalence and mortality trends in the coming decades. The emphasis on interdisciplinary mitigation strategies, spanning public health policy, technological innovation, and environmental sustainability, underscores the relevance of the paper to both scientific inquiry and policy development. Overall, the paper's depth, clarity, and forward-looking vision make it a valuable contribution to the emerging field of climate-health interaction studies.

13.CONCLUSION

Climate change has evolved into one of the most profound determinants of global health in the modern era, influencing disease dynamics across cardiovascular, pulmonary, and thermoregulatory systems. This review underscores how rising global temperatures, erratic weather patterns, and deteriorating air quality are not merely environmental phenomena but critical biological stressors that challenge human physiological resilience. The complex interplay between environmental instability and health outcomes highlights that climate change is both an ecological and medical emergency requiring immediate, integrated intervention.
As evidenced through this review, cardiopulmonary and thermoregulatory diseases are no longer confined to conventional medical paradigms but are deeply intertwined with environmental shifts and socioeconomic disparities. Understanding their interconnection provides a foundation for developing climate-adaptive healthcare models capable of mitigating morbidity and mortality in a warming world. Future resilience depends not only on advancing scientific knowledge but also on reimagining healthcare infrastructure, policy frameworks, and global cooperation.
Ultimately, addressing climate change as a health crisis demands an alliance between science, technology, and governance. By embedding environmental consciousness into public health strategies, humanity can begin to transform a crisis of climate into a catalyst for innovation, equity, and survival.

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