

The Far Reaching Effects of Global Warming on Human Health: Understanding the Impact

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Abstract

Human health has several attributes of which one of the most important is the environment. The fast changing environment in the world encompassing global warming, emerging pollution and massive urbanization have posed newer challenges. While the human genome tends to adapt with the ever-changing newer environment but often the same remains unable to cope up with. The implications of the changing climate on health already include the disruption of food systems, a surge in pathogen based infectious diseases, mental health issues along with illnesses caused by food, water, and vectors. Climatic extremities like Floods, hurricanes, and other types of catastrophic weather conditions are becoming more frequent. In addition, global warming threatens several of the social and economic variables including physical well-being, living standards, and availability of medical services. These global warming related health issues disproportionately impact the most sensitive section of the society including females, children, underprivileged people, older people and people with chronic medical concerns. Taking government policies in consideration world over and know major devices to safeguard the environment, it now becomes duty of healthcare personnel to adjust and readjust the priorities ensuring health for all.

Keywords: Global Warming, Heat Stress, Illness, Climate Change, Environment, Health

1. Introduction

Global warming is the term used to describe the exceptionally rapid rise in Earth's average surface temperature during the last few decades as a result of greenhouse gas emissions due to burning of fossil fuels. Tracking back to Earth's history, the planet itself has warmed and cooled time and again. These climatic changes occurred when the planet got a greater or decreased amount of sunlight as a result of small variations in its orbit as the Sun's energy fluctuated or the environment altered in the past, but these changes occurred for ages without human interventions. But since last few decades, the current climatic warming is occurring much more rapidly than past warming events with another force that has drastically started to influence Earth's climate change, known as humanity. According to provisional State of the Global Climate Report 2022 produced by the UN's World Meteorological Organization, Global temperatures in 2022 were likely to end about 1.15C above the average in pre-industrial times, making it the fifth or sixth hottest year on record. The World Health

Organization (WHO) reports that climate change is responsible for at least 150,000 deaths per year, a number that is expected to double by 2030.

Our Planet had maintained a uniform temperature over part centuries, however on time spans ranging from decades to millennia, the changes observed in the past two eras are quite drastic alterations, and the frequency of these climatic variations is much higher than it has ever been in the previous years [1]. This change is happening with catastrophic speed with an increase in greenhouse gases and devastating effects on lives and livelihoods around the globe. There had been alterations in rate of precipitation, coastal land displacement, increase in cropping time, acute food insecurity, catastrophic events, melting glaciers, and spread of pathogen-based illness apart from affecting mental wellbeing of individuals

2. Current Human Health Scenario

Global warming is posing a heavy threat to mankind creating major health concerns that are critically affecting the most susceptible sectors of the society. The adverse effects of global warming, along with other natural or artificially induced health stressors, affects human health and diseases in many ways by intensifying existing health issues and creating newer ones in future. Not everyone is equally at risk, some groups are more vulnerable to climate health impacts due to their age (children and seniors), gender (especially pregnant women), social marginalization (linked in some areas

to indigenous population, poverty or migration status), or other medical conditions such as HIV. Climatic alterations can have an impact on life cycle of insects/pathogens and their virulence, which can change how pathogen-borne diseases propagate. More diseases connected to water can occur because of increased precipitation, storm surge, and sea temperature it can also deteriorate food quality and safety increasing the risk of foodborne diseases. The various climatic change drivers, their impact on the environmental and human health is summarised in Table 1.

S.No.	Climate change	Environmental impact	Health Impact
1.	Rise in temperatures and prolonged heat stresses	Increase in average temperatures globally	Rate of heat related illnesses and death increases
2.	Changes in rainfall pattern and runoff affecting salinity of coastal regions	Shellfish and other aquatic life contaminated with water borne infections eg. <i>Vibrio vulnificus</i>	Increase in water borne illnesses due to <i>Vibrio vulnificus</i> and other related microbial strains. Increase in diarrhoea, intestinal illnesses, wound and blood stream infections.
3.	Increase in humidity, temperatures and more than average season length	Increased growth of pathogens, seasonal shifts in incidence of <i>Salmonella</i> exposure	Increase in food-borne diseases and gastro-intestinal disturbances
4.	Changing precipitation patterns and temperatures along with pollution	Worsened air quality leading to ozone layer depletion, increase in particulate matter and pollen counts in air	Impacts risk of premature deaths, acute and chronic cardiovascular and respiratory illnesses.
5.	Excessive precipitation, storms, hurricanes and tsunamis	Leads to contaminated water bodies, increased debris and disruption of essential infrastructure.	Increases rates of drowning, injuries, Mental health issues, gastrointestinal disturbances etc.
6.	Extreme seasonal weather patterns	Increased frequency of vector borne diseases with geographically expanded tick activity	Risk of Lyme disease causing bacteria increases.

Table 1: Table Showing Specific Examples of Climate Change and Their Effect on Human

3. Effects of Heat Waves

Even in industrialised nations, heat waves increase mortality because, generally speaking, mortality rises at both above and below optimal temperatures. The heightened risk of mortality in regions witnessing lower temperatures could be due to epidemic spread of virus based infections along with secondary bacterial infections and heart problems [7-12]. Decrease in temperatures majorly affects cardiovascular and respiratory functions of the body sometimes resulting in bronchospasm and various immune related disturbances. Living in a confined and congested setting and avoiding outside exposure also elevates the risk of various illnesses especially during winters. Apart from this it has been seen that colder climate populations and people suffering from chronic conditions such high blood pressure, cardiovascular and metabolic issues are more susceptible to extreme heat and it related consequences [13-16]. There has been a documented 14% heightened risk of myocardial infarctions every time there is an increase in regional climatic change across various parts of the world. During periods of high heat and precipitation, the number of hospitalised asthma patients' increases [17]. According

to a theory, fungal spores transported by wind can be released during thunderstorms, severe rainstorms, and periods of strong wind, increasing exposure to these allergens. The occurrence of urolithiasis increasing is another phenomenon noted during the hot season. The relationship of excessive heat with sweat production, dehydration, and renal function is thought to be responsible for this, which explains why hotter climates appear to have a higher prevalence of kidney stones.

4. Diseases Carried by Vectors

The distribution, prevalence and intensity of vector-borne illnesses is majorly driven by climate change. Global warming leads to hike in average temperature that result in prolonged and warmer summers, early spring and short cold season which are more favourable factors for numerous vectors spreading a variety of vector-borne diseases. The weather variability can occasionally result in vector/pathogen adaptation and shifts or expansions of their geographic ranges. Such shifts can regulate disease incidence relying on vector-host interplay, host immunity, and pathogen evolution. Local differences in weather, ecosystem modification,

the wide range of animal hosts, and behavioural change that affects vector-human interaction are all factors that can affect the transmission of infectious diseases.

Climate, particularly temperature, precipitation, and humidity, has a significant impact on the growth and survival of ticks, their animal hosts (such as deer), and the bacterium that causes Lyme disease. Milder winters cause fewer disease-carrying ticks to die throughout the winter in areas where Lyme disease already present. As a result, there may be more ticks in certain regions, which raise the possibility of getting Lyme disease there. Similarly to this, the other illness affected by global warming is West Nile virus. It's crucial to keep people from getting the West Nile virus because at present there are no vaccination strategies or treatments for it in humans, and recovering from a severe illness could take weeks or months [2]. The effects of altering vector and pathogen distributions, the effects on human behaviour, and the linkages between weather variables, vector range, and vector-borne pathogen prevalence need to be quantified. Better vector monitoring and tracking of infections must be implemented to address these issues.

5. Waterborne Diseases

Global warming affects the quality of water in various ecosystems like saltwater, fresh, marine etc apart from manmade water reservoirs. This is majorly affected by repurcution of climatic change like extreme and altered rainfall patterns and seasonal variations. These climatic changes often results in flooding which releases industrial, agricultural and sewage runoff into different water bodies propagating bacterial species like Legionella and Escherichia coli (E. coli) that lead to adverse health effects from waterborne illnesses [18]. Apart from this swimming or fishing from these water bodies and consumption of affected seafood are the most common pathways of exposure. The most common illnesses caused by contaminated water are diarrhoea, giardiasis, dysentery, typhoid fever, E. Coli infection, and salmonellosis. Adverse health effects can include pain in the gastrointestinal, reproductive, neurological systems, and other symptoms. Continuous exposure can have long-lasting health impacts [18]. Even though diarrheal disease prevalence and intensity are driven by Though patterns vary by location and pathogen, diarrheal illnesses like salmonellosis and Campylo bacteriosis are often more prevalent when temperatures are higher. These diarrheal illnesses were found to accelerated with changing pattern of rainfall and temperatures in any region [3].

6. Mental Health and Stress-Related Disorders

Extreme weather conditions were found to have substantial negative impact on mental well being. The prevalence of psychiatric illnesses and injuries linked to natural catastrophes is rising, but they are understudied, underreported, and not properly monitored. As in post-traumatic stress disorder (PTSD), the mental health condition may be directly related to the incident or it may develop into a chronic condition [5]. Following natural disasters,

the rate of mental health concerns increases for both at-risk individuals and those without any mental health issues, a pattern referred to as "common reactions to abnormal events." These reactions could be momentary or, in some situations, continue for a lifetime. Historical events where natural disasters like hurricanes, floods and heat waves hit earth's surface in the past, for instance, showed significantly high rates of anxiety and post-traumatic stress disorder. It has been reported that the rate of psychopathology in the world rose by about 17% during disasters [6]. Also, within few months after the natural calamity, mental and emotional well being of approx. one-third of the community, with persistent ailment burden anticipated to last a lifetime. PTSD affects rescue professionals as well as catastrophe victims, with an incidence of 10% to 20% [6]. Furthermore, some mental health individuals are more susceptible to global warming than others. The numbers of suicides vary seasonally and rise in summers, suggesting that depression and other mental illnesses are likely to be an implication warming temperatures. Dementia and schizophrenia are risk factors for hospitalisation and mortality during heat waves because their medications may have an impact on temperature regulation control of our bodies and lead to hyperthermia [4].

7. Neurological Disorders

A large-scale study from US, in which they collectively studied historical weather and environmental regional weather statistics with psychological issues of nearly two million randomly selected native residents between 2002 and 2012 [19]. The study reported that a thermal scale rise of above 30°C would dramatically increase the occurrence of mental disorders, offering empirical evidence that GW threatens human MH. Immediate small duration impacts of routine average temperature on patient admission in hospitals due to mental issues was examined in a Chinese study [20]. They discovered a significant correlation of hospital admissions and visits because of mental/psychological issues with rise in temperature above 24.6°C and when using 18.3 °C as average thermal threshold. In comparison to the median temperature, the relative probability of experiencing extremely hot temperatures was 1.27 (33.1 C, percentile 99%). In contrast, incidence of anxiety/depression rose during cold weather, according to other research [21-23].

High temperatures were observed to dramatically increase the incidence of mania cases. Unexpectedly, there was no age difference between the groups but the males were found to be at a lower risk than their female counterparts [24]. In contrast, people with advancing age were more susceptible to higher temperatures and women were at lower risk of heat related mental depression disorder than men (Hazard Ratio = 1.14 vs. 1.18) [25]. The mental wellness state of humans is influenced by weather extremities and climatic changes that include criminal behaviour, traumatic stress, sleep disorders, depression and anxiety, irritability, social avoidance, and drug/alcohol abuse [26-28]. These environmental alterations may have other substantial consequences on mental health, including an increase in suicide mortality, both directly

and indirectly [29-31]. It is widely known that vertebrates operate phenotypic adaptations in response to continuous exposure to hot environmental temperatures, and that heat acclimation depends on the thermoregulatory centre's flexibility in the hypothalamus [32, 33].

In addition to this, heat stress (HS) is an environmental condition that increases the generation of mitochondrial ROS [34]. Possible reasons for increase in free radical concentration during higher temperatures could be attributed to increased generation of transition metal ions and lower expression of superoxide dismutase 1 [35]. Through the transfer of an electron to oxygen, the latter create superoxide anions. Reduced antioxidant defence, altered metal homeostasis, and elevated ROS levels brought on by HS may all worsen MD as well as mitochondrial dysfunction [36, 37]. It has been observed that a protein TRPV4, a sort of ion channel, is involved in detecting the surrounding temperature. It is a brain-expressed nonselective Ca²⁺-permeable cation channel that is active between 25 and 34 °C [38, 39]. TRPV4 is expressed in cells throughout the central nervous system (CNS), including neurons, glial cells [40-42], and vascular endothelial cells and is crucial in CNS diseases [43, 44]. It was noted to modify the blood brain barrier (BBB), which is significant [45,46]. A number of mental disorders have been associated with disrupted BBB [47]. In conclusion, although it is unclear exactly what mechanisms are responsible for development of mental health issues due to heat stress. However, there could be possible involvement of Heat shock protein levels, furthermore, heat stress could increase ROS, that cross the BBB resulting in a rise in protein influx in the brain.

8. Metabolic Syndrome

8.1. Hypertension

An increase in the temperatures results in loss of water from the body resulting in increase in osmotic concentration of blood. The kidneys play a role in controlling blood volume and blood pressure and were found to be affected by higher temperatures. Additionally, change in climatic conditions was found to impact and vary the kidney function profile in individuals [48]. Autoimmunity clearly plays a role in essential hypertension. Immune cell infiltration in the kidney is a common finding that is associated with abnormal sodium excretion [49, 50]. Sodium intake affects about 30-40% of people suffering from elevated blood pressure [51]. Furthermore, malfunctioning in pressure-natriuretic synergy caused by abnormalities in proper vessel relaxation and sympathetic nervous system is all involved in the induction of elevated blood pressure [52]. There is a significant involvement of generalized inflammation, T-cells, autoimmunity, and HSPs in regulation of blood pressure. The balance between T-cell-induced inflammation and T-cell suppressor responses is critical in T cells [52]. The nephrotic and vascular autoimmune responses could result from inflammatory effect caused by alteration of neoantigen levels, as well as movement of immune responsive peptides present within cells (e.g., HSPs). This was supported by the fact that HSP70 might be involved in a pathway mediating the impact of

heat on development of hypertensive state in any individual [49]. Furthermore, an increase in levels of HSP70 in kidneys in high sodium-induced elevation in blood pressure results in induction of clonal propagation of CD4+ T cells [50]. To summarise, we could postulate that the interplay between autoimmunity and salt excretion by kidney, autoimmunity against Immuno dominant HSP's (HSP70), and improper vascular relaxation induced by inflammation are all cumulatively responsible for the development of hypertensive phenotype due to heat distress.

8.2. Type 2 Diabetes mellitus

Population based studies suggest a link between temperature of surrounding with risk of diabetes, where a study from different tropical cities in Philippines collected mortality data of diabetic patients along with the regions climatic data that was retrieved from the National Oceanic and Atmospheric Administration on every day basis [53]. They discovered that both increase and decrease in temperatures could pose an individual a heightened risk of disease occurrence. However, they also reported that a slightly lower temperature could also low at times play a protective role in diseases occurrence [53]. In order to characterise the relationship between ambient temperature and the disease, data from 4.5 million consultations of patients reporting with diabetes was conducted by English general practitioners between the years of 2012 and 2014 were analysed [54]. The results showed a link between disease phenotype and localised temperature recorded on the patient's residence. Additionally, this got worse on days with extreme temperatures, especially when it was hot outside. The third study tracked over 500,000 hospitalisations for diabetes-related reasons in Brazil between 2000 and 2015 [55]. It was discovered that an average rise of 5°C in daily temperature resulted in a 6% increase in hospitalisation for diabetes. The authors estimated that on an average 7.3% of patients getting hospitalized with diabetes in high temperature weather are ascribed to effect of heightened temperatures that manifest disease repercussions.

Apart from this, HSPs were also found to be responsible for providing protection from high temperatures as the first line of defence. These chaperones may help patients with diabetes manage some issues such oxidative stress and inflammation, however HSP levels are decreased as a result of the loss of homeostasis [56, 57]. Particularly, diabetes patients have decreased HSP72 gene expression and insulin-stimulated glucose absorption [58]. It's interesting to note that short heat exposure, such that experienced in a sauna or hot tub, has been proven to lower diabetes-related markers like fasting blood glucose, HbA1c, body mass index, possibly through boosting HSP70 expression [59]. Furthermore, HSPs gene activation could develop into novel therapeutic target for combating diabetes [58].

9. Spiritual Healing

A man thinks he is the master of the destiny. However, many wise man, agree that God is the master of destiny. It is therefore, expected that humankind will have abiding faith in God. However,

not everybody subscribe to the view. The concept of spiritual healing is directly related to the faith in nature (God-super consciousness). Under any diseased condition, medical support is important but at the same time, deep/strong hope coupled with power of supplications is equally important. While spiritual healing does not come under the purview of precision medicine directly, however, supplications have been found to speed up the process of healing and patients recover faster.

10. Major Contributors of Global Warming and Global State Of Climate Action

Major contributors of global warming are typically countries with high levels of greenhouse gas emissions, particularly from the burning of fossil fuels and industrial activities. Table 2 illustrates a list of nations that play a significant role in contributing to global warming, along with an assessment of the current status of climate action at the global level.

Country	Major Contributors to Global Warming	Current State of Climate Action
China	High greenhouse gas emissions from fossil fuel use and industry	Signatory of the Paris Agreement, but still heavily reliant on coal
United States	High greenhouse gas emissions from fossil fuel use and industry	Rejoined the Paris Agreement, implementing some climate policies
India	High greenhouse gas emissions from fossil fuel use and agriculture	Signatory of the Paris Agreement, increasing renewable energy capacity
Russia	High greenhouse gas emissions from fossil fuel use and industry	Signatory of the Paris Agreement, but slow progress on emission cuts
Japan	High greenhouse gas emissions from fossil fuel use and industry	Committed to reducing emissions, investing in renewable energy
Germany	High greenhouse gas emissions from fossil fuel use and industry	Ambitious emission reduction targets, leader in renewable energy
Brazil	Deforestation and land-use change, emissions from agriculture	Signatory of the Paris Agreement, some efforts to curb deforestation
Indonesia	Deforestation and land-use change, emissions from agriculture	Signatory of the Paris Agreement, committed to reducing deforestation
Australia	High greenhouse gas emissions from fossil fuel use and industry	Mixed climate policy, heavily reliant on coal
Canada	High greenhouse gas emissions from fossil fuel use and industry	Signatory of the Paris Agreement, taking steps towards emission cuts

Table 2: Major Contributors of Global Warming and Global State of Climate Action

11. Conclusion

Global warming constitutes the biggest concerns in the present scenario with the increasing incidences of climate-related illnesses. In addition to having an obvious influence on people's livelihoods, it is expected to have a negative and significant effect on people's health. The populations of nations with the smallest contributions to global warming are those most at risk from illnesses and fatalities brought on by rising temperatures. The repercussions of global warming, like other impacts of rising temperatures, are especially severe in low-income nations where urbanisation has happened quickly and without preparation. Vector-borne diseases, for example, have a mortality rate that is nearly 300 times higher in developing countries than in developed ones. This represents a significant cause of mortality, a burden of disease and health inequity, a hindrance to socioeconomic development, and a strain on health services. Thus, climate change should be presented only as an environmental issue but as a global health concern to engage active public participation. Apart from health other factors like migration, security, and societal repercussions are also implicated as a result of this change that directly affects the people. Additionally, the failure of health systems as a result of catastrophes like floods which are a result of global warming, can

also have an influence on health and the delivery of health care. Thus, it is very critical for the public and the government to come together for building climate-resilient health systems for tackling this global concern.

Ethics Declaration

Conflict of Interest

The author declares no competing interests.

Human and Animal Rights and Informed Consent

This article does not contain any studies with human or animal subjects performed by any of the authors.

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