



Impact of Climate Change on Human Health: A Review of Literature

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Abstract

Background: The present article was written with the background knowledge of climate change and highlighting its relationship with health issues especially in tropical and Sub-Saharan African regions. There is a significant impact of global climate change on human health. This article highlighted the fundamental pillars of health including food security, air quality and water safety.

Introduction: An anthropogenic activity such as urbanization, industrialization, and infrastructure development needs land. Deforestation is one of the straightforward ways to acquire lands for these developments. Large scale of deforestation taken place in last century led to increase of Green House gas (GHG) emission which subsequently led to global warming. Increase in atmospheric temperature led to many health problems notably, increase in incidence of infectious disease, emergence of new infectious agents, respiratory and cardiovascular diseases. Further, increased GHG emission led to depletion of ozone layer and increased quantity of UV radiation on earth causes various form of malignancies in human beings apart from poor air quality which contain particulate matters (PM), responsible for cardiovascular, respiratory illness and lung cancers. The effort of global environmental organization is to agree to cut the GHG emission to hold the increase in the global average temperature to well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels as per Paris agreement 2015, so that emergence of diseases and increase in incidence of these disease can also be decreased.

Aims: This article aims to highlight the impact of climate change on health and to find out the possible measures to reduce the GHG emission and increase the quality of health affected by climate change and global warming.

Conclusions: Active measures should be planned and implemented by local bodies and international organizations and to devise effective global strategies for mitigation and adaptation so that the adverse effect of climate change may not be detrimental to human health.

Keywords: Climate Change; GHG Emission; Deforestation; ARR; Health Hazards

Abbreviations

PM: Particulate Matters; GHG: Global Greenhouse Gas; LCA: Life Cycle Assessment; EPA: Environmental Protection Agency; NMSC: Nonmelanotic Skin Carcinoma; BCC: Basal Cell Carcinoma; SCC: Squamous Cell Carcinoma and Melanoma; ARR: Afforestation Reforestation and Revegetation; IPCC: Intergovernmental Panel on Climate Change; UVR: Ultraviolet Radiation.

Introduction

The global climate is changing and will continue to change. Climate change will affect, in profoundly adverse ways, some of the most fundamental pillars of health: food, air and water. Research is only beginning to examine the potential health implications and indicates significant vulnerabilities. The ongoing increase of GHG emissions from anthropogenic activities caused dramatic climate changes. The global rise in average temperature is causing an increase of events that have adverse effects on human health. The cardiopulmonary system and the gastrointestinal tract are particularly vulnerable to global warming. There is also a higher risk of infectious and allergic diseases. There is a need to implement at a global level effective strategies for mitigation and adaptation meant to reduce the impact that global warming has on human health. WHO 2009 report for protecting health from climate change posed to global public health. It highlighted the current and potential future impact on the basic determinant of health such as clean air and water sufficient food and adequate shelter. The changing climate led to air pollution, transmission of disease through water and contaminated food, compromised agriculture production and high risk of extreme weather events. Infectious diseases like cholera, malaria, and other vector-borne diseases are particularly sensitive to climate change conditions. This report stressed that a global response to address climate change although a complex issue requires collaboration across societies [1].

Effects of global climate change on human health may be direct or indirect. Until now investigators were mainly focused on the direct effects of extreme weather events, such as heat waves, droughts, cyclones and tropical storms, for which empirical data are readily available and correlations are easily demonstrable [2]. Indirect effects related to climate changes, such as the worsening of ambient air quality and the impact on infectious disease diffusion are also relevant for human health [3].

GHG emission notably due to vehicular pollution, wildfire, and industrialization along with deforestation also lead to depletion of Ozone layer and increased in global temperature, humidity, atmospheric pressure, precipitation,

wind pattern, water salinity. Reduction in glacier size led to many health issues such as distribution of allergens and infectious diseases, effect on cardiopulmonary and gastrointestinal system. Climate changes also increased the prevalence of infectious disease especially vector borne diseases such as typhus, malaria, cholera, dengue, and West Nile Viral fever. Depletion in ozone layer also led to increase in incidence of skin cancers [4].

Health Impacts of Climate Hazards

The contribution of climatic conditions on the clinical manifestations of cardiopulmonary disorders has been recognized by several studies indicating a seasonal variation of acute coronary syndromes, myocardial infarction and related morbidity and mortality rates more in winters and, less in summers but still alarming [5,6].

Human activities for the last 50 years or more have caused climate changes which cost more than 150,000 lives annually world wide, due to cardiovascular and respiratory diseases and heatwaves. There is an altered disease transmission pattern and malnutrition due to crop failure. Although long term data and significant socio-economic influence are required to attribute specific disease pattern expansion. Tropical regions are highly vulnerable for climate variability leading to health issues to especially around Pacific and Indian Ocean and Sub-Saharan African region [7].

Heat and drought greatly contribute to the occurrence of wildfire, which has dramatically increased in frequency in the USA, Russia and Mediterranean areas. Smoke emissions can travel hundreds of kilometers downwind of fire areas, exposing many people to a noxious mixture of particulate matter (PM), other harmful compounds and depletion of ozone layer [8-10].

In a recent analysis, malnutrition was found to be responsible for a substantial proportion of global deaths due to pneumonia in children under the age of 5 years. It has been estimated that sub-Saharan Africa and South Asia, whose food supplies are already limited, will have the largest reductions in food supply as a result of climate changes [11,12].

Climate warming and related changes, not only periods of droughts but also of massive rainfall and floods, are likely to reduce the availability of safe water and lowering of ground water level. It is well demonstrated that low rainfalls are associated with the prevalence of diarrheal diseases in children. A number of studies have convincingly demonstrated that diarrheal diseases increase as temperatures increase, ranging from a 3% to 11% increased risk per 1°C of temperature increase. On the other hand, the intense rainfalls

that are associated with hurricanes and floods are damaging the safety of drinking water supply. Warmer temperatures increase the concentrations of air pollutants. Particulate matter (PM) showed stronger evidence of negative impact on health as compared to ozone. No possible threshold for PM can be ascertained but exposure to PM is linked to cardiovascular, respiratory disease including asthma and lung cancers. PM size is crucial, with smaller particles ($PM < 2.5 \mu m$) penetrate deep into the lungs and can be associated to plaque formation in arteries leading to atherosclerosis and very small particles ($PM < 0.1 \mu m$) potentially reached to other organs [13]. A review published in 2007 by the US Environmental Protection Agency (EPA) concluded that high ozone exposure owing to heat waves was associated with a reduction in lung function and exacerbation of respiratory symptoms (including aggravation of asthma) in patients with preexisting respiratory diseases, contributing to more premature deaths in people with heart and lung disease [14]. A meta-analysis of 39 studies by Bell and colleagues found a positive association between mortality and short-term exposure to ozone, particularly cardiovascular and respiratory mortality [15]. There is also strong evidence for the negative impact of particulate matters on health, especially on the cardiovascular system [16-18]. Fine and ultrafine particles, which penetrate deeper into the lung alveoli and may pass into the bloodstream, are the most dangerous [19,20].

Changes in temperature and rainfall patterns, particularly extreme events, might enhance the spread of infectious diseases [1]. Many infectious agents and their vectors are sensitive to climatic conditions. For example, both *Salmonella* and *Vibrio cholera* proliferate more rapidly at higher temperatures: *Salmonella* in the animal gut and food, and the cholera agent in the water [21]. In the last few years, several investigators have focused on the relation between short-term climatic variation and occurrence of infectious diseases (especially vector-borne). Studies in South Asia and South America have documented an association between malaria outbreaks and the El Niño Southern Oscillation cycle [22-24]. Similarly, in the Asian-Pacific region, El Niño seems to have influenced the occurrence of outbreaks of dengue fever [25].

Change of Dietary Pattern may Reduce GHG Emission

Change of diet pattern from non-vegetarian to vegetarian is associated with greater benefit both in terms of health and mitigating the climate change impact. Food systems have a significant role in environmental issues and public health challenges as a quarter of GHG emission is notably attributed to food systems.

Unhealthy diet and obesity identified as major risk factors related to high morbidity and early mortality especially in developing countries. Economic gain obtained by dietary change may surpass the environmental benefit gained from preventing climate change. Vegetarian diet decreases the GHG emission as animals like cow and lamb's ruminant have more methane emission an important greenhouse gas and further, upbringing of livestock needs more land and energy, as compared to crop farming [26].

In another study highlighted that the Spanish Ministry of Health launched the NAOS Strategy in 2005 which extends far beyond the healthcare and educational areas, promoting healthy diets and physical activity. It is emphasized that global shift to meat and processed food potentially increase emissions by 80% by 2050, while plant-based diets could reduce emissions by up to 50%. The authors highlighted that a diet based on Spanish dietary guidelines can reduce GHG emissions by promoting plant-based products and reducing meat consumption, recommending the inclusion of life cycle-based indicators to enhance the environmental performance of dietary recommendations [27].

It is important to note that the food chain contributes about 30% of global greenhouse gas (GHG) emissions and is a significant contributor to global warming. Therefore, measures should be taken to reduce these emissions for sustainability of global warming. It is crucial for sustaining Earth's food production capacity. Life cycle assessment (LCA) has become a popular method for analyzing the environmental impacts of food production and consumption. The study by Corrado et al 2019 assessed the GHG emissions of three balanced dietary patterns (omnivorous, vegetarian, and vegan) for an Italian population, considering the emission during food production, cooking methods, and food waste contributes about 66%-74% of total emissions. They conclude that domestic behaviors like cooking and food waste significantly influence total GHG emissions [28].

Climate Change and Development of Cancer

Climate change may have direct and indirect effects on the development of cancer and on cancer care. Climate change-related disasters can expose people to cancer-causing substances, or carcinogens, in the environment. Wildfire smoke, vehicular exhaust, industrial waste contains several carcinogens, such as formaldehyde and benzene. Exposure to these carcinogens leads to an increase in cancer risk factors, reduce food access and nutritional quality, impede health behaviors, and disrupt cancer care delivery. It is not surprising that natural disasters disrupt cancer care and lead to worse outcomes for patients.

Populations disproportionately burdened by cancer are

also those at greatest risk of harm from these changes. The impacts of climate change on cancer outcomes are complex, requiring multilevel interventions [29].

Stratospheric ozone depletion, global warming and ambient air pollution have contributed to the rising incidence of cutaneous malignancies worldwide and will continue to negatively influence skin cancer rates for many decades to come [30]. Skin cancer is the one of the most common cancers globally, rising significantly in the latter part of the 20th century, especially among fair-skinned populations mainly due to depletion of ozone layer [31,32]. Nonmelanotic skin carcinoma (NMSC), including basal cell carcinoma (BCC) and squamous cell carcinoma and melanoma (SCC), account for the majority of skin cancers [33].

Increase of Ultraviolet radiation (UVR) at the earth's surface leads to a higher incidence of skin cancer. For every 1% decrease in ozone layer thickness, melanoma incidence is projected to increase by 1% to 2%, SCC by 3% to 4.6%, and BCC by up to 2.7% [34]. It has been observed that absolute humidity, mean temperature, diurnal temperature range increases the risk of malignant tumor mortality. Analytical studies have revealed that females are more sensitive to humidity, while males need to be cautious of high diurnal temperature variation [35]. Relation of climate change with hematological malignancies was studied and observed that the importance of HIV/AIDS, aging, environmental pollution, dry season, and climate phenomena like El Niño and La Niña are determinants of hematologic malignancies among black anemic patients in the tropical region [36].

Measures to be taken to Combat the Climate Change and its Impact on Health

Increased green spaces such as Afforestation Reforestation and Revegetation (ARR) policies have positive impact on adaptive capacity and urban population, GHG emission and various health issues. Achieving a low carbon emission global economy and its association on public health has become a political challenge rather than a technical or economic issue in this twenty first century. It is necessary for governments to take specific measures to establish a framework for international carbon pricing and emphasizing the role of renewable energy sources in low- and middle-income countries and to support health related benefits associated with climate change mitigation. It has become important for health care workers and environmentalists to sit together to find out the way of implementing the Paris agreement for reducing global temperature by limiting anthropogenic activities [37].

There is significant relationship between adaptation progress and factors such as engagement in international

and national environmental governance, perception of public sector corruption, population size, and national wealth. Population and country GDP are important factors for assessing the adaptation levels, but they are insufficient without strong policy commitments to environment management.

Incentive framework is an important indicator of countries commitment for addressing health impact of climate change [38].

The World Health Organization's published a report "Protecting Health from Climate Change: Vulnerability and Adaptation Assessment" in 2013 analyzed the health impacts of climate change and outlined the strategies for assessing and adapting to vulnerabilities. The report highlighted the effects of climate change on health, identifying vulnerable populations, and integrating climate considerations into public health planning by international bodies such as The Intergovernmental Panel on Climate Change (IPCC). The report also highlighted the importance of evaluating climate-sensitive health outcomes and developing adaptation measures. It also stressed the need to consider both climatic and non-climatic factors, such as infrastructure and socioeconomic conditions, when assessing vulnerabilities. The aim of this report is to protect public health by addressing the related health factors influenced by climate change [39].

Methodology

Methodology which can be implemented for combating climate change and mitigating its impact on health required multifaceted approach, which include as follows:

Policy Making and Governance

Implementing the climate policies enforce the regulation to reduce GHG emission like carbon pricing, carbon credit system and use of renewable energy and non-conventional energy sources. Investing in solar and wind energy, motivating public to invest and give subsidies for installation of roof top solar panels and windmills etc. Strong governance is required for these activities. Both governmental and non-governmental organizations can be useful for implementation. Global cooperation is also important for implementing all these measures on a large scale. Policies for conservation of forest and afforestation, especially in tropical zones, are important. An integrated approach, stakeholder engagement, policy support, sustainable livelihoods monitoring, and evaluation are key concepts for these policies. The framework aims to create a balance between environmental conservation and socio-economic development, ensuring that restoration efforts contribute positively to the well-being of local communities

are important for success of such policies [40].

Strengthening the Public Health Infrastructure

Improvement in public health infrastructure system for better respond to climate related health issues, including heatwaves, vector borne diseases and air quality problems. Disease surveillance and data collections to monitor the outbreak and effective measures to be taken to combat such situation always a backbone for such plannings. Community engagement in decision making process to ensure health policies and response to local needs. Accountability, transparency, resource allocation and institutional capacity are some other important factors to focus on in some of the areas to curtail the health disparity in different locations. Health education is also an important area to cover to combat the disease spread and controlling the vector born disease [41].

Careful Urban Planning and Infrastructure Development

Very important to combat the impact of climate change on health hazard is the careful planning of infrastructure. Infrastructure development is need of hours for increasing global population. City design considering the green spaces efficient non-polluting public transport are some of the important measures to reduce urban heat island effect. Build such infrastructure that withstand extreme weather conditions such as floods, hurricanes, and heatwaves. Effective and systemic waste management practice to reduce GHG from landfills and promote recycling and composting should be implemented and considered as one of the important components in such infrastructure development [42].

Agriculture and Food Security

Sustainable farming practice that increase the resilience to climate changes as crop diversification, conservation agriculture and agroforestry are important methods to improve the need of food with mitigating the climate change and health. Effective water management for agriculture as well as safe drinking water are other important factors for relating health and climate. Strengthening the food security programme to ensure nutritious food during climate induce disruption are other important policies to be discussed at global as well as local level [43].

Conclusions

Climate changes can influence the emergence of infectious diseases, affect food yields and nutrition, the supply of safe water and thereby increase the risks of

climate-related disasters. It is also actually evident that climate changes are not only an environmental and economic problem but also play a significant role in public health. There is urgent need to increase the knowledge to formulate effective measures for mitigation and adaptation focusing on reducing the potential impact of GHG emission and future climate changes. It should also be highlighted that global coordination to improve air quality, by decreasing fossil fuel usage. They suggested that the use of non-conventional energy sources such as solar energy, wind energy etc. reduced GHG emission considerably and justified the economic cost of climate mitigation and adaptation. Some authors discussed the change of pattern of diet may reduce the GHG emission as upbringing of cattle, lambs and poultries requires more energy and their ruminant increases the GHG emission, but simultaneously shifting the dietary pattern from non-vegetarian to vegetarian may increase the grass eaters more on the earth and their grazing may deplete the green lands on earth, therefore, a balanced ecosystem is necessary to protect our earth for future generation.

Simultaneously it should also be noted that governmental or non-governmental organizations should take measures to promote green spaces and establish frameworks for international carbon pricing to achieve a low-carbon global economy. Effective climate change mitigation requires collaboration between healthcare workers and environmentalists, especially to implement agreements like the Paris Agreement.

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