



Global health impacts due to infectious diseases and climate change: A narrative review

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ABSTRACT

According to the World Health Organization (WHO), environment is explained in terms of human health, such as physical, chemical and biological factors that are external to a person and all the related behavioral changes that affect population health. Quality of life and health is generally affected by people's interaction with the environment. The purpose of this narrative review was to address various global health impacts such as heat wave impact, impact of floods and droughts, impact of allergens and impact of air pollution. A major emphasis of this review was on climatic impact on a variety of infectious diseases, particularly the interplay between 'global warming' and its effects on transmission of infectious diseases across the world. An analysis of vector borne disease transmission, infectious disease transmission modeling, in the backdrop of global warming, the concept of 'one health' and the effects of rising sea levels, which are purported to be due to global warming, were some of the highlighted issues addressed in this review. Towards the end, attention was drawn towards the limitations of addressing vector disease transmission related insufficient studies particularly studies which conduct predictive modeling of infectious disease transmission, which were marred by lack of innovation.

Keywords: environment, climate, global warming, infectious diseases, global health

INTRODUCTION

Environment is everything that surrounds us human beings. There is constant interaction between people and the environment. People's activities or interactions with their environment reflects and impacts their quality of life, and in turn their health. According to the World Health Organization (WHO), environment is explained in terms of human health, as all the physical, chemical and biological factors that are external to a person and all the related behavioral changes that affect people's health¹.

People constantly interact with their environment by performing various activities. They mold the environment so as to get maximum benefits from it. In the process of getting beneficial productivity from the environment people are using the vital natural resources available in the environment². It is seen that constant and continuous use of these natural resources over the period is causing its exhaustion. The other effect of human activities on the environment is causing pollution by the emission of greenhouse gases, and other pollutants. These pollutants or greenhouse gases which are emitted due to human activities are disturbing the environmental health and disrupting the delicate

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ecological balance. They are also harmful to people as they can cause adverse health effects and spread diseases. Some pollutants like greenhouse gas emissions are also responsible for climate change and unfavorable changes in the global environment. Hence, it is observed that human activities are directly or indirectly responsible for altering the global environment³.

The greenhouse gases have adversely affected the environmental equilibrium. These gases which are emitted due to a variety of human activities like burning fossil fuels, and coal have caused climate variations such as making the earth warmer than before and other unfavorable weather effects⁴. These effects have reflected its negative impact on ecology, human health, agriculture, economic problems, society, and on energy issues³.

Global Warming

Global warming is explained by United States Environmental protection Agency (EPA) as recent and continuous rise in global temperatures observed especially near earth's surface. Climatic changes are one of the effects due to global warming. The greenhouse gases are responsible for causing global warming and changing weather patterns associated with it. The United States EPA explains climate change as any significant change in the measures of climate lasting for an extended period of time³. These climate changes or weather patterns are observed changes in the temperature, the rate and flow of wind and precipitation rates over many years. Hence, global warming reflects the effects on climate and directly or indirectly affects humans.

Over a brief period it has been observed that earth's average temperature is rising. It has risen by 1.4 degree Fahrenheit over a century and is predicted to continue to rise in the future. These small changes in the temperature lead to a potentially larger effect on the global environment. The rise in the temperature leads to climate and weather change and causes unfavorable conditions like floods, famines, heat waves, intense rains, rising sea levels, ice melting and similar undesirable conditions³.

Impact on Human Health

The undesirable climate change caused due to global warming has increased the temperatures above normal or average degrees. It will be difficult for humans to cope up with the rising temperatures. The warmer temperatures will lead to hotter days and the population will suffer from heat -related health problems and illnesses. This in turn will also increase the concentration of air and water pollutants. The extreme weather conditions like storms, and heavy rainfall, will directly impact humans by causing illnesses and spreading diseases⁵.

Effect of heat waves

The excessive heat or high temperatures due to global warming will subsequently lead to health conditions like heat stroke and dehydration. Excessive heat wave is one of the major causes of weather related deaths. This climate change will adversely affect population health and well-being. People will be using their air-conditioners much more than usual to cool themselves. Hence, this constant and continuous usage of power machines will produce pollution in the form of greenhouse gases. The heat wave will adversely affect the health of children, elderly, and people with medical history. Hence, the heat waves will cause more heat related health conditions, will lead to air pollution and its related diseases and in adverse conditions cause casualties⁵.

Health effects of flood and drought conditions

The extremes in weather patterns due to global warming can pave a path for extreme events. There can be heavy rainfall causing flooding conditions and at times there can be no rainfall at all in some parts of the world causing drought like conditions. These conditions can play an important role in causing health problems in people worldwide. Floods can lead to food and water contamination leading to diarrheal diseases due to vector infestation. This can also cause malnutrition in people. There can be respiratory problems in people due to crowding and due to wet weather conditions; diseases like asthma and other bronchial conditions

can flare up. The drought condition can lead to dehydration and extreme heat can lead to problems like stroke and thermal stress⁶. These conditions can cause air pollution due to constant use of energy machines like air conditioners. The other health conditions which can impact population health are mental illnesses like depression, anxiety disorders and post-traumatic stress disorders⁵. Hence extreme weather conditions can have various deleterious effects on human health and mental well-being.

Impact of air pollution

A warmer weather and climate change is associated with air pollution. Air pollution can cause increased changes of harmful ground level ozone which is full of pollutants. This kind of pollution has adverse effects on human health. The pollution in air gives rise to respiratory illnesses and diseases. Bronchitis and asthma cases are seen due to decreased air quality. This can affect children, the elderly, as well as people who work outdoors more than others. People with chronic respiratory problems or medical history of respiratory diseases are also affected more than the general population⁵.

Impact of allergens on human health

Changes in the climate patterns can alter the spring season. In spring season, pollens are released in the air. These pollens are known to spread allergic reactions causing respiratory problems like rhinitis, skin problems like rash and other allergies. Climatic changes has caused prolonged spring pollen season which also comes earlier than normal⁵. This can lead to increase in population allergies and cause health discomfort.

CLIMATIC IMPACT ON INFECTIOUS DISEASES

Impact on food-borne diseases

It is observed that bacterial growth flares up in warmer temperatures; hence increase in the average temperature will lead to rapid bacterial growth in foods. This can lead to contamination of food with bacteria such as salmonella. Food-borne illnesses lead to gastrointestinal diseases with symptoms like diarrhea, dehydration, abdominal cramps and in some severe cases can be even fatal.

Heavy rainfall leading to flood conditions can lead to food contamination. Alternately gastrointestinal infectious diseases can be caused as a result of fresh water being contaminated by sewage water hence in turn contaminating food crops and fresh food supply. Infectious diseases like cholera, typhoid, and salmonella infection can spread due to this food contamination⁵.

Impact of water-borne diseases

There can be flood like conditions prevailing due to heavy rainfall which can cause fresh water supply to be contaminated with sewage water. This can cause water-borne diseases like giardiasis, cholera and other gastrointestinal illnesses. Symptoms like diarrhea, vomiting, headache, and abdominal discomfort can be seen in people infected with these illnesses⁵.

Impact on tick-borne diseases

Tick-borne diseases like Lyme's disease cause symptoms such as fever, rash, headache and joint pain, as temperature and humidity impacts the tick's life cycle⁶. Rise in the temperatures is going to affect the geographic location of ticks as they will continue their range of spread to the north side of the globe⁵.

Impact on rodent-borne diseases

Climatic changes are going to cause extremes in the weather leading to heavy rainfall. This weather condition can lead to increase in the spread of rodent-borne diseases like leptospirosis⁶.

Impact on vector-borne diseases

The question "Is global warming or climate change real?" seems to be very well answered as of present due to various research studies which have clearly indicated the rise in global temperatures^{7,8,9}. The next important question deals with the environmental effects of global warming on human health, particularly in terms of infectious disease transmission to humans. Rise in ambient temperatures and rise in sea levels are predominantly pointed out to be two important factors which perpetuate the disease transmission. When it comes to effects of global warming on disease transmission in humans, a variety of

complex factors seem to be intertwined in a systems and episystems perspective. Some of the elements of a systems dynamic framework which collectively facilitate disease transmission include climate change and variability, deforestation, human population overgrowth, poverty and water change/rainfall patterns¹⁰. Caught in this intriguing meshwork of environmental factors is a triad of vector-pathogen-host interaction which sustains this cycle of disease transmission¹¹. In a quest to understand the details of these systems interplay in terms of future projections of disease transmission, speculations are ripe about vector competence and its effect in predicting disease transmission¹². Although presently this area of research is understudied, there are some pointers towards maintaining a general well-being of the environment by poverty reduction, better and improved health care and better surveillance protocols¹³.

The 21st century has shown us an intersection of multiple disciplines such as epidemiology, environmental health, entomology, veterinary science and genetics in terms of approaches towards understanding disease transmission particularly by arthropod-vectors. This probably happens due to two closely linked phenomena such as increased temperatures resulting in higher transmission potential and increased abundance of water which leads to increase in vector larval habitats and increase in vector population growth rate¹⁰.

In a study which challenged the notion of increasing temperatures leading to increased transmission of vector-borne diseases, researchers highlighted the complexity of relationship between parasite development, parasite survival and transmission during various temperature ranges. They concluded that vector competence (the maximum number of infectious mosquitoes) decreases at highest temperatures¹². This is a contrasting thought then to the much discussed role about infection transmission via mosquitoes and needs to be further studied.

While the disease transmission among human beings is an important aspect of global warming studied across worldwide; the concept of 'one health' continues to thrive at present. This concept proposes to merge medical and veterinary science from the aspects of approaching various dimensions of disease transmission, such as presence of human population, presence of domestic animals and wildlife and the impact of climatic change on these. However, these factors as earlier pointed out in the dynamics of systems theory, are interlinked such that each of these can be further dissected into modern life trends (global travel, pet ownership and culinary habits, industrialization sequelae (megacities, food-chain industry automatization & global trade intensification), and politics (state reform, conflict, free trade economy) for human factors. Similarly observed are species variability, biodiversity and ecosystem disruption as pathogen-related factors along with climatic effects such as El Nino southern oscillation and global warming¹⁴.

Global warming effects such as increase in disease transmission due to mosquito vectors causing malaria and encephalitis are well documented¹⁵ but there is also quite a bit of evidence of global warming effects on migratory birds which can transmit a novel zoonotic infection when they change their routes due to rise in temperatures¹⁶.

The vector borne transmission of diseases particularly, diseases such as malaria and dengue are understudied when it comes to their relation to rising sea-levels which in turn are caused by global warming. In a study which had several hypotheses related to the vector tolerance such as abilities of mosquitoes to adapt to changes in the salinity levels in sea water as well as fresh waters, researchers tried to address some of the existing issues in vector related disease transmission in humans. They couldn't come to a conclusive verdict, as there are varied amount of mosquito species depending on the part of the world such as Asia, Americas, Europe etc. Also the kinds of waters in which they breed are diverse and some can adapt to salinity and some can't. It is also difficult to predict which ones may become infectious over the time¹⁵.

Other than the much studied effects of global warming on mosquito-driven disease transmission there is extremely insufficient evidence about infectious diseases other than the mosquito-driven. A case in study of the effects of global warming causing diarrhea needs a special mention. Some empirical studies done in the past found a positive correlation between rise in temperatures and number of Salmonella, Campylobacter and E. coli infections across the world. These have raised eyebrows about a probable cause effect relationship between global warming and diarrheal effects. There is certainly a need to address this issue by generating more empirical data on this association and better modeling studies to prove a causal relationship¹⁷.

Climatic change as we understand today may be looked at and studied in a very different way in future with emerging technologies and climate modeling. It is hypothesized based on few current studies that scientists in future will have to use innovative statistical techniques particularly for determining trend analyses and non-linear associations between climate changes and disease incidences. Furthermore causal criteria need to be established such as biological sensitivity evidence, meteorological evidence of climate change and effective evidence for epidemiological or entomological change. There is clearly a need of many more studies in future which need to address these factors⁸. A recent analysis was conducted by the health sector of the US National Health Assessment to determine any gaps between climate variability and outcomes such as a) temperature related mortality, b) effect of extreme weather events, c) health effects related to air pollution, d) water and food-borne diseases and e) vector and rodent-borne diseases. They concluded an overall uncertainty in the future projections of associations between climate variability and the above five mentioned variables. There are clearly deficiencies in gap analyses particularly due to reliable local and regional climate change projections leading to quantifying the attributable fraction of the disease to climate changes. Speculations are ripe for some health events such as heat events and flooding increasing morbidity and mortality in humans but

that cannot be conclusively discussed for effects of global warming leading to increased morbidity and mortality among humans with disease transmission as an intermediary variable¹⁸.

Scientists often use multiple models to predict disease transmission in humans globally and derive a trend analysis report but the important question to ask here is "can the modeled trend mimic what is happening in natural surroundings?" Also have we considered how does these trends factor into seasonal changes over years, over a wide distribution of geographic areas and over varying human genetic traits over a longitudinal span of years? These are some of the intriguing questions which are at best speculated at present times and hope to be answered in the future.

CONCLUSION

Global warming is a subcomponent of climatic change happening worldwide. This universal rise in temperatures has disrupted not only environmental factors such as biodiversity, rainfall, heat trends, air pollution, sea level changes but also creating a plethora of existing and emerging infectious diseases in humans. Over a decade of research shows us that vector –borne disease transmission exists due to global warming leading to rise in variety of diseases such as malaria, dengue, and Japanese encephalitis to name a few¹⁹.

The current research has been marred by understudied factors such as vector competence, vector-adaptation to saline waters and role of global warming in spread of diarrheal diseases world-wide. Future projections in the study of global warming and either their associative and/or causative relationships with spread of human infectious diseases are speculative and need to be backed by robust, replicative studies underlining the importance of emerging trends and role of health agencies and health sectors in preventing or managing these global outcomes.

There is a need for effective national and community based public health programs promoting population awareness and preparedness for climate change due to global warming⁵. These

climate changes can cause extreme events like extreme cold to excessive heat waves; flood or drought conditions hence awareness and preparedness nationally and at an individual level becomes crucial. There should be backup support system so as to reduce the impact of extreme climate change on population health and well-being. Also crucial is a trans-disciplinary approach where physicians, environmentalists, veterinarians and climate experts work united to manage and transform adverse health impacts due to climatic variability and climatic emergencies.

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