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Climate Change and It's Impact on Global Health

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Abstract: **There is near unanimous scientific consensus that greenhouse gas emissions generated by human activity will change Earth's climate. The recent (globally averaged) warming by 0·5ºC is partly attributable to such anthropogenic emissions. Climate change will affect human health in many ways—mostly adversely. We review the published estimates of future health effects of climate change over coming decades. Historically, the industrialized countries have been the primary contributors to emissions of CO_2. Before the prospect of anthropogenic climate change emerged, epidemiologists were not greatly interested in climate-health relations. Modern epidemiology has focused mainly on studying risk factors for non-communicable diseases in individuals, not populations. Malaria is the world's most widespread and fatal vector borne disease, killing 1-2 million persons a year, the majority of these being young children. Meanwhile, there have been occasional studies examining deaths due to heat waves, some epidemiological studies of air pollution incorporating temperature as a covariate, and a continuation of the longer standing research interest in meteorological effects on microbes, vectors, and infectious disease transmission. Scientists project that warmer temperatures from climate change will increase the frequency of days with unhealthy levels of ground-level ozone, a harmful air pollutant, and a component in smog. Overall, the health risks of climate-related thermal stress, floods, and infectious diseases have been the most amenable to conventional epidemiological studies. Climate change, as an environmental hazard operating at the global scale, poses a unique and ''involuntary exposure'' to many societies, and therefore represents possibly the largest health inequity of our time. According to statistics from the World Health Organization (WHO), regions or populations already experiencing the most increase in diseases attributable to temperature rise in the past 30 years ironically contain those populations least responsible for causing greenhouse gas warming of the planet**

Keywords: **climate change, Global Health, WHO, epidemiological studies greenhouse gas emissions.**

1. INTRODUCTION

Climate change is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years. It may be a change in average weather conditions, or in the distribution of weather around the average conditions (i.e., more or fewer extreme weather events). Climate change has to do with a change of climate which is directly or indirectly attributed to human activity that changes the global atmosphere over the natural climate fluctuation. Climate change is caused by factors such as biotic processes, variations in solar radiation received by Earth, plate tectonics, and volcanic eruptions. Climate is probably the most important determinant of vegetation patterns globally and has significant influence on the distribution, structure and ecology of forests[1]. Several climateve gestation studies have shown that certain climatic regimes are associated with particular plant communities or functional types [2,3,4,5.] It is therefore logical to assume that changes in climate would alter the configuration of forest ecosystems [6,7]. The Third Assessment Report of IPCC8 concluded that recent modeling studies indicate that forest ecosystems could be seriously impacted by future climate change. Even with global warming of 1-2°C, much less than the most recent projections of warming during this century [9], most ecosystems and landscapes will be impacted through changes in species composition, productivity and biodiversity[10]. These have implications for the livelihoods of people who depend on forest resources for their livelihoods[11].Climate change is one of the most important global environmental challenges facing humanity with implications for food production, natural ecosystems, freshwater supply, health, etc. According to

the latest scientific assessment, the earth's climate system has demonstrably changed on both global and regional scales since the pre industrial era. Further evidence shows that most of the warming (of 0.1^0C per decade) observed over the last 50 years, is attributable to human activities1. The Intergovernmental Panel on Climate Change (IPCC) projects that the global mean temperature may increase between 1.4 degradation and desertification. Increasing global temperatures will result in rising sea levels. Populations that inhabit small islands and/or low-lying coastal areas are at particular risk of severe social and economic disruptions from sea-level rise and storm surges that could destroy cities and disrupt large coastal livelihoods. Climate change is one of the most important global environmental challenges, with implications for food production, water supply, health, energy, etc. Addressing climate change requires a good scientific understanding as well as coordinated action at national and global level. Particulate matter is the term for a category of extremely small particles and liquid droplets suspended in the atmosphere. Fine particles include particles smaller than 2.5 micrometers (about one ten-thousandth of an inch). These particles may be emitted directly or may be formed in the atmosphere from chemical reactions of gases such as sulfur dioxide, nitrogen dioxide, and volatile organic compounds. Higher air temperatures can increase cases of salmonella and other bacteria-related food poisoning because bacteria grow more rapidly in warm environments. **Climate change** is a change in the statistical distribution of weather over periods of time that range from decades to millions of years. It can be a change in the average weather or a change in the distribution of weather events around an average (for example, greater or fewer extreme weather events). Climate change may be limited to a specific region, or may occur across the whole Earth. In recent usage, especially in the context of environmental policy, climate change usually refers to changes in modern climate. It may be qualified as anthropogenic climate change, more generally known as "global warming" or "anthropogenic global warming.

2. CONTRIBUTION OF INDUSTRIALIZED AND DEVELOPING COUNTRIES

Historically, the industrialized countries have been the primary contributors to emissions of CO_2. According to one estimate, industrialized countries are responsible for about 83% of the rise in cumulative fossil fuel related CO_2 emissions4 since 1800. In the 1990s, they accounted for about 53% of the 6.3 GtC/year, which was releasd as CO_2 from fossil fuel combustion. These countries have contributed little to the release of CO_2 from the burning of vegetation, which is largely due to tropical deforestation during this period. The imbalance of responsibility for global warming is striking when comparing across nations. Average global carbon emissions approximate one metric ton per year (tC/yr) per person. In 2004, U.S. per capita emissions neared 6 tC/yr (with Canada and Australia not far behind), and Japan and Western European countries range from 2 to 5 tC/yr per capita. Yet developing countries' per capita emissions approximate 0.6 tC/yr, and more than 50 countries are below 0.2 tC/yr (Marland et al., 2007)[12]. It is this lowest level of emissions, in fact, that the IPCC recommends reaching (or 0.3 tC/yr per capita) if society is to stabilize the atmosphere at twice preindustrial levels, assuming a leveling of world population approximating 10 billion (Houghton et al., 1996)[13].

3. DISEASE AND ECONOMIC BURDENS: THE CASE OF MALERIA

Malaria is the world's most widespread and fatal vector borne disease, killing 1-2 million persons a year, the majority of these being young children. In fact, an estimated 25% of all-cause mortality in children aged 0-4 years is directly attributed to malaria (Sachs and Malaney, 2002) 30. Malaria transmission is highly influenced by climate and is one reason why sub-Saharan Africa is strongly affected by climate change on the WHO global burden of diseases map. One biological reason for malaria's persistence in the tropics lies with the ''base case reproduction rate'' of malaria, which is much higher in the warm and humid tropics compared to temperate regions.

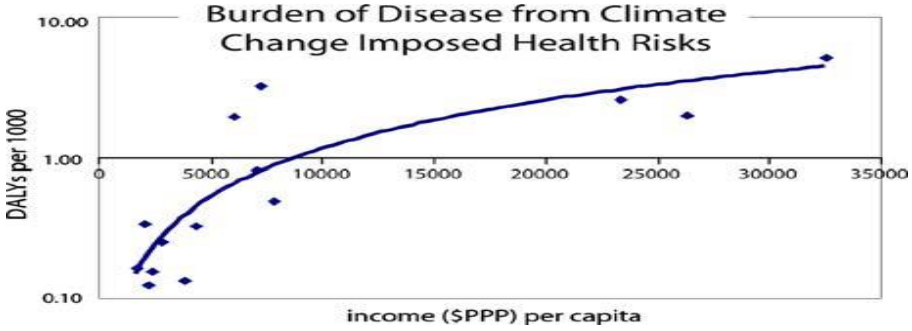

FIGURE: 1

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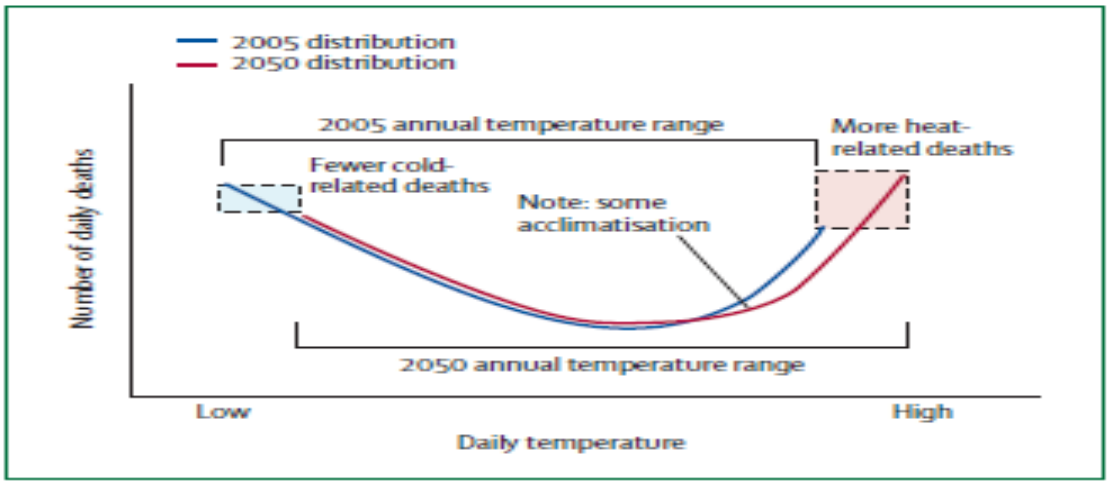

Figure 2: **Schematic representation of how an increase in average annual temperature would affect annual total of temperature-related deaths, by shifting distribution of daily temperatures to the right**
Additional heat-related deaths in summer would outweigh the extra winter deaths averted (as may happen in some northern European countries). Average daily temperature range in temperate countries would be about 5–30°C.

4. THERMAL STRESS

Populations typically display an optimum temperature at which the (daily or weekly) death rate is lowest. Mortality rates rise at temperatures outside this comfort zone.[14] Figure 2 shows a typical U-shaped relation. The trough represents the comfort zone; the steeper (right-side) arm of each line shows the mortality increase at hot temperatures, and the shallower (left-side) arm of each line shows the increase with colder temperatures. The temperature-mortality relation varies greatly by latitude and climatic zone. People in hotter cities are more affected by colder temperatures, and people in colder cities are more affected by warmer temperatures.[14,15].Regions where housing provides poor protection against cold have higher excess winter mortality than expected for that location[16]. In the UK and some other northern high latitude countries, seasonal death rates and illness events are higher in winter than in summer [17–21,25,26,27]. There, the role of cold temperature itself, beyond the role of seasonal infectious agents (influenza in elderly people [28] and respiratory syncytial virus in infants [29] and seasonal hematological changes remains unresolved. Most heat wave deaths occur in people with pre-existing cardiovascular disease (heart attack and stroke) or chronic respiratory diseases. People living in urban environments are at greater risk than those in non-urban regions[23] Thermally inefficient housing[24] and the so-called urban heat island effect (whereby inner urban environments, with high thermal mass and low ventilation, absorb and retain heat) amplify and extend the rise in temperatures (especially overnight) [22]

5. CLIMATE AND HEALTH PROGRAM

Health Effects:

Weather and climate have affected human health for millennia. Climate experts are particularly confident that climate change will bring increasingly frequent and severe heat waves and extreme weather events, as well as a rise in sea levels. These changes have the potential to affect human health in several direct and indirect ways, some of them severe. A brief overview of the likely health effects of increased temperatures and extreme weather events is provided here. Links to additional information about these and other potential health effects − such as air quality, vector-borne and zootomic diseases, water- and food-borne diseases and mental health.

Increased Temperatures:

Heat exposure has a range of health effects, from mild heat rashes to deadly heat stroke. Heat exposure can also aggravate several chronic diseases, including cardiovascular and respiratory disease. The results can be severe and result in both increased illness and death. Heat also increases ground-level ozone concentrations, causing direct lung injury and

increasing the severity of respiratory diseases such as asthma and chronic obstructive pulmonary disease. Higher temperatures and heat waves increased demand for electricity and thus combustion of fossil fuels, generating airborne particulates and indirectly leading to increased respiratory disease.

Over a longer time period, increased temperatures have other effects ranging from drought to ecosystem changes that can affect health. Droughts can result in shortages of clean water and may concentrate contaminants that negatively affect the chemistry of surface waters in some areas. Drought may also strain agricultural productivity and could result in increased food prices and food shortages, worsening strain on those affected by hunger and food insecurity in the U.S. and elsewhere. Ecosystem changes include migration of the vectors (organisms that do not cause disease but transmit infection by carrying pathogens from one host to another) and animal hosts that cause certain diseases prevalent in the U.S., such as Lyme disease and Hantavirus. The dynamics of disease migration are complex and temperature is just one factor affecting the distribution of these diseases.

Winters will also be warmer, which is likely to lead to a decrease in illness and death associated with exposure to cold. In addition to this general warming trend, climate change will bring increased weather variability, the results of which are difficult to predict.

Extreme Weather Events:

The direct effects of extreme weather events include drowning from floods, injuries from floods, and structural collapse. Indirect effects outnumber the direct effects and likely will be more costly. Potential indirect effects include aggravation of chronic diseases due to interruptions in health care service, significant mental health concerns both from interrupted care and geographic displacement, and socioeconomic disruption resulting from population displacement and infrastructure loss. Sea level rise increases the risk from extreme weather events in coastal areas, threatening critical infrastructure and worsening immediate and chronic health effects. Salt-water entering freshwater drinking supplies is also a concern for these regions, and increased salt content in soil can hinder agricultural activity in coastal areas.

Green House Effect:

- The atmosphere is kept warm enough for life as we know it with a natural blanket of greenhouse gases at an average temperature of 15 degrees C.
- Due to human emissions, the blanket of greenhouse gases has become thicker and therefore trapping the heat which causes global warming.
- The biggest source of human generated greenhouse gas emissions comes from fossil fuels.

Other indirect exposures and health effects:

Climate change is a complex phenomenon and a range of unanticipated ecological effects may result. Many of these ecosystem effects could have indirect health effects. Increased concentrations of ground-level carbon dioxide and longer growing seasons could result in higher pollen production, worsening allergic and respiratory disease. Increased carbon dioxide concentrations in sea water may cause oceans to grow more acidic and is likely to contribute to adverse ecosystem changes in the world's tropical oceans. This would have potentially dramatic implications for fisheries and the food supply in certain regions of the world. Major regional ecosystem stresses may result in mass population movement and conflict, with significant health effects. Some of these concerns are low-probability high-impact events, and could have significant health impacts on a global scale.

Key Points:

- A warmer climate is expected to both increase the risk of heat-related illnesses and death and worsen conditions for air quality.
- Climate change will likely increase the frequency and strength of extreme events (such as floods, droughts, and storms) that threaten human safety and health.
- Climate changes may allow some diseases to spread more easily.

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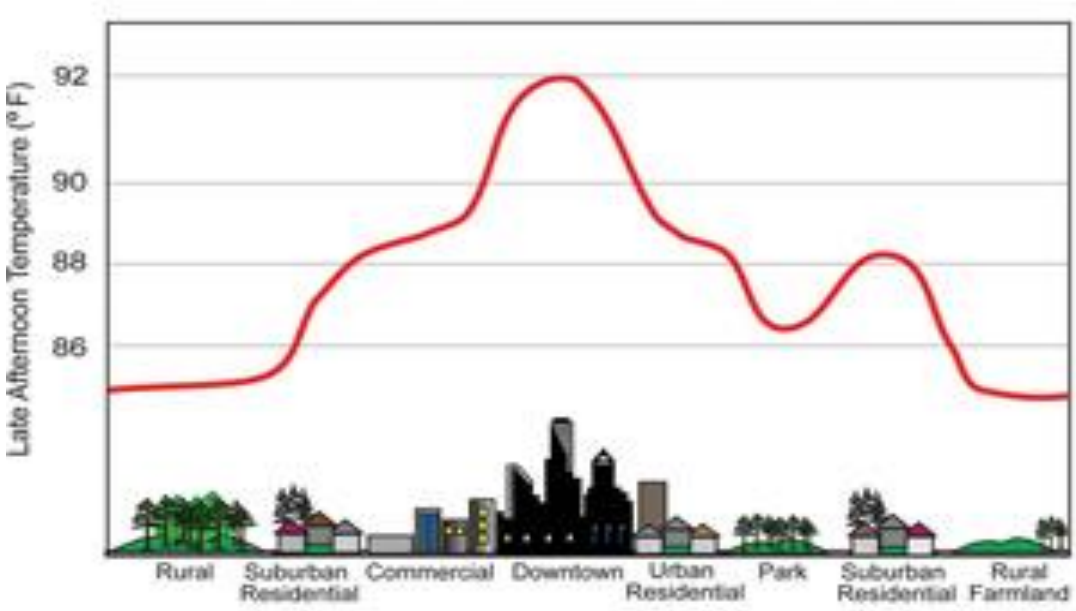
6. IMPACTS FROM HEAT WAVES

Heat waves can lead to heat stroke and dehydration, and are the most common cause of weather-related deaths[31,32]. Excessive heat is more likely to impact populations in northern latitudes where people are less prepared to cope with excessive temperatures. Young children, older adults, people with medical conditions, and the poor are more vulnerable than others to heat-related illness. The share of the U.S. population composed of adults over age 65 is currently 12%, but is projected to grow to 21% by 2050, leading to a larger vulnerable population [31].



The "urban heat island" refers to the fact that the local temperature in urban areas is a few degrees higher than the surrounding area. Source: USGCRP (2009)

Sun setting over a city on a hot day. Source: EPA (2010)

The "urban heat island" refers to the fact that the local temperature in urban areas is a few degrees higher than the surrounding area. Source: USGCRP (2009)

Impacts from Extreme Weather Events:

The frequency and intensity of extreme precipitation events is projected to increase in some locations, as is the severity (wind speeds and rain) of tropical storms[31]. These extreme weather events could cause injuries and, in some cases, death. As with heat waves, the people most at risk include young children, older adults, people with medical conditions, and the poor. Extreme events can also indirectly threaten human health in a number of ways.

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Flooded streets in New Orleans after Hurricane Katrina in 2005. Source:FEMA (2005)

- Reduce the availability of fresh food and water [32]
- Interrupt communication, utility, and health care services[33]
- Contribute to carbon monoxide poisoning from portable electric generators used during and after storms[33]
- Increase stomach and intestinal illness among evacuees[31]
- Contribute to mental health impacts such as depression and post-traumatic stress disorder (PTSD)[31].

Impacts from Reduced Air Quality:

Despite significant improvements in U.S. air quality since the 1970s, as of 2008 more than 126 million Americans lived in counties that did not meet national air quality standards[33]

Increases in Ozone:

Scientists project that warmer temperatures from climate change will increase the frequency of days with unhealthy levels of ground-level ozone, a harmful air pollutant, and a component in smog[32,33].

- Ground-level ozone can damage lung tissue and can reduce lung function and inflame airways. This can increase respiratory symptoms and aggravate asthma or other lung diseases. It is especially harmful to children, older adults, outdoor workers, and those with asthma and other chronic lung diseases[34]

- Ozone exposure also has been associated with increased susceptibility to respiratory infections, medication use, doctor visits, and emergency department visits and hospital admissions for individuals with lung disease. Some studies suggest that ozone may increase the risk of premature mortality, and possibly even the development of asthma[31-34].

- Ground-level ozone is formed when certain air pollutants, such as carbon monoxide, oxides of nitrogen (also called NO_X), and volatile organic compounds, are exposed to each other in sunlight. Ground-level ozone is one of the pollutants in smog[32,33]

- Because warm, stagnant air tends to increase the formation of ozone, climate change is likely to increase levels of ground-level ozone in already-polluted areas of the United States and increase the number of days with poor air quality[31]. If emissions of air pollutants remain fixed at today's levels until 2050, warming from climate change alone could increase the number of Red Ozone Alert Days (when the air is unhealthy for everyone) by 68% in the 50 largest eastern U.S. cities [31]. (See Box below "EPA Report on Air Quality and Climate Change.")

Changes in Fine Particulate Matter:

Particulate matter is the term for a category of extremely small particles and liquid droplets suspended in the atmosphere. Fine particles include particles smaller than 2.5 micrometers (about one ten-thousandth of an inch). These particles may be emitted directly or may be formed in the atmosphere from chemical reactions of gases such as sulfur dioxide, nitrogen dioxide, and volatile organic compounds.

- Inhaling fine particles can lead to a broad range of adverse health effects, including premature mortality, aggravation of cardiovascular and respiratory disease, development of chronic lung disease, exacerbation of asthma, and decreased lung function growth in children[35].

- Sources of fine particle pollution include power plants, gasoline and diesel engines, wood combustion, high-temperature industrial processes such as smelters and steel mills, and forest fires [35].

Due to the variety of sources and components of fine particulate matter, scientists do not yet know whether climate change will increase or decrease particulate matter concentrations across the United States[36,37]. A lot of particulate matter is cleaned from the air by rainfall, so increases in precipitation could have a beneficial effect. At the same time, other climate-related changes in stagnant air episodes, wind patterns, emissions from vegetation and the chemistry of atmospheric pollutants will likely affect particulate matter levels[32]. Climate change will also affect particulates through changes in wildfires, which are expected to become more frequent and intense in a warmer climate[36].

Changes in Allergens:

Climate change may affect allergies and respiratory health[34]. The spring pollen season is already occurring earlier in the United States due to climate change. The length of the season may also have increased. In addition, climate change may facilitate the spread of ragweed, an invasive plant with very allergenic pollen. Tests on ragweed show that increasing carbon dioxide concentrations and temperatures would increase the amount and timing of ragweed pollen production[31,32,38].

7. IMPACTS FROM CLIMATE-SENSITIVE DISEASES

Changes in climate may enhance the spread of some diseases[31].Disease-causing agents, called pathogens, can be transmitted through food, water, and animals such as deer, birds, mice, and insects. Climate change could affect all of these transmitters.

Food-borne Diseases:

Higher air temperatures can increase cases of salmonella and other bacteria-related food poisoning because bacteria grow more rapidly in warm environments. These diseases can cause gastrointestinal distress and, in severe cases, death[31].

Flooding and heavy rainfall can cause overflows from sewage treatment plants into fresh water sources. Overflows could contaminate certain food crops with pathogen-containing feces [31].

Water-borne Diseases

Heavy rainfall or flooding can increase water-borne parasites such as *Cryptosporidium* and *Giardia* that are sometimes found in drinking water. These parasites can cause gastrointestinal distress and in severe cases, death.

- Heavy rainfall events cause storm water runoff that may contaminate water bodies used for recreation (such as lakes and beaches) with other bacteria[38]. The most common illness contracted from contamination at beaches is gastroenteritis, an inflammation of the stomach and the intestines that can cause symptoms such as vomiting, headaches, and fever. Other minor illnesses include ear, eye, nose, and throat infections[32].

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8. ANIMAL-BORNE DISEASES

Mosquitoes favor warm, wet climates and can spread diseases such as West Nile virus.

- The geographic range of ticks that carry Lyme disease is limited by temperature. As air temperatures rise, the range of these ticks is likely to continue to expand northward[38]. Typical symptoms of Lyme disease include fever, headache, fatigue, and a characteristic skin rash.

- In 2002, a new strain of West Nile virus, which can cause serious, life-altering disease, emerged in the United States. Higher temperatures are favorable to the survival of this new strain [31].

The spread of climate-sensitive diseases will depend on both climate and non-climate factors. The United States has public health infrastructure and programs to monitor, manage, and prevent the spread of many diseases. The risks for climate-sensitive diseases can be much higher in poorer countries that have less capacity to prevent and treat illness [38].

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