WILL CLIMATE CHANGE AFFECT PARASITE- HOST RELATIONSHIP?

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Abstract

Research examining the causal relationships between climate, climate change and parasite ecology is the focus of increased attention. Understanding how parasites are likely to be affected by climate change requires an examination of the interactions between climate and parasite ecology and transmission. The distribution, prevalence and abundance of a parasite is determined by availability of susceptible hosts, environmental thresholds for development (for either free-living or parasite stages in poikilothermic intermediate hosts and vectors) and resilience, bounded by upper and lower tolerances for survival. Furthermore, life history parameters such as how free living stages are distributed in the environment (as eggs or larvae) and the potential for arrested development can interact with climate and shorter-term weather patterns to influence distribution.

Thus, to a great extent, the actual or realized distribution of parasites in time and space is influenced largely by climatic factors. These factors also contribute to the ecological parameters determining parasite survival and hence transmission. Thus, the changes in climatic variables can alter parasite ecology by affecting host and geographic distribution, infection pressure, prevalence and intensity of parasites and can do so directly (via free-living stages) or indirectly (by affecting hosts). Shifts or expansion in distribution, prevalence and intensity of parasites will be closely linked with that of their hosts and will be dependent on numerous factors driving change. The effects of environmentally detrimental changes in local land use and alterations in global climate disrupt the natural ecosystem and can increase the risk of transmission of parasitic diseases to the human population.

Key words: *Climate change; Parasite; El Niño; Ecology*

Introduction

Climate is usually defined as the average weather, (i.e. short term - hours to days - fluctuation), over a period of years and in a particular geographic region. Climate involves variations in interactions among different components of the climate system: the atmosphere, the oceans, sea ice, and land features[1]. Changes in any of the climate system components, whether internal or from external forces, can cause climatic variation and change. The aggregate effect of temperature, precipitation, humidity, solar radiation and wind which are reflected in the type of vegetation in plant communities contribute to determining the nature of vector and parasite populations[1].

In earlier times, changes in climate occurred solely through natural processes resulting from phenomena such as changes in the output of the sun or slowing of ocean circulation. Today, human activities also contribute to climate change: fossil-fuel combustion (coal, oil, and gas) increasing the concentration of CO_2; deforestation reducing CO_2, absorbing capacity of forested areas; industrial activity and biomass burning resulting in emissions of gases such as carbon monoxide (CO) and volatile organic compounds (e.g. butane, propane) that undergo photo-oxidation in the presence of nitrogen oxides to form tropospheric ozone; doubling of atmospheric methane (CH4) from pre-industrial levels[2] with current levels at the highest ever[3]. Halogenated compounds that do not exist naturally are now present in substantial amounts in the atmosphere, and have high greenhouse warming properties, in addition to their destructive effect on the stratospheric ozone layer[4].

Small changes in the mean climate can produce relatively large changes in the frequency of extreme weather events and frequency and severity of heat waves [5]. Warmer temperatures are expected to lead to a more vigorous hydrological cycle, causing increased precipitation intensity and more rainfall events. However, ironically, higher mean temperatures may also lead to reduced soil moisture due to enhanced evaporation[6].

The impact of climate change

Climatic factors vary naturally around the world without obvious notice, and at the same time comfortably maintaining the various natural and ecological systems. In the last two-three decades, however, this variation has gone beyond natural levels that climatologists are now in general agreement that the world has begin to experience the process of global "climate change". The assessment report of the Inter-governmental Panel on Climate Change (IPCC) confirmed that human activities, principally the burning of fossil fuel, have increased the atmospheric concentration of important green house gases, which may result in a warming of the earth's surface[7]. In his work on "planetary overload", McMichael[8] stated that "human- induced climate change is now compromising the sustainability of human development on the planet because it threatens the ecological support systems on which life depends".

It is generally accepted that global socio-economic development and health interventions have improved the general standard of living in the recent times but the resulting deteriorating global environmental conditions or factors are on the other hand, affecting human health (figure 1). The major global environmental changes significantly affecting health include climate change and ozone depletion[9]. Ozone in the stratosphere is produced by photolytic destruction of oxygen. It is a protective shield to life on earth, preventing much of the sun's ultraviolet (UV) radiation; especially UV with shorter wavelength from reaching the Earth. As a result, any change in atmospheric concentration of ozone causes changes in the radioactive levels. Since the industrial revolution, human activities have increased the atmospheric concentration of what is known today as greenhouse gases. These are carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O) and chlorofluorocarbons (CFCs)[10].

The photochemical reactions of these greenhouse gases with the ozone, "the green house effect", have now led to serious depletion of the protective or ozone layer. The effects of this depletion have far reaching effect on man and life on Earth. Problems associated with climate change and ozone depletion are numerous and interrelated. For instance, the depletion of ozone layer in the stratosphere as a result of greenhouse effect causes global warming[11]. Such changes in the concentration of greenhouse gases are projected to lead to regional and global changes in climate and climate-related parameters: temperature, humidity precipitation etc. This is to the extent that IPCC[7] has projected an increase of global mean surface temperature of 1^0C - 3.5^0 C by year 2100.

In man, the health impact of ozone depletion and climate change cannot be separated because of the synergistic effect. For instance, with increased UV-B radiation on earth, the human immune system is likely to be affected; and this will reduce the affected population's resistance to infections and parasitic diseases. The potential health impact of climate change is grouped into direct and indirect effects[12] depending on whether they occur predominantly via the impact of climate variables upon human biology or are mediated by climate-induced changes on biological and biogeochemical systems. For the indirect effect, it has been noted that the resulting temperature and precipitation changes might actually influence the behaviour and geographical distribution of vectors of parasitic diseases, and thus change the incidence and distribution, (as well as emergence and re-emergence) of vector-borne diseases[13].

In this aspect of our discussion we want to bring to focus the impact and potential impact of climate change on emerging and reemerging parasitic disease using vector-borne parasitic diseases as example. The important determinants in the spread of vector-borne parasitic diseases are especially influenced by fluctuation in climatic variables, notably temperature, precipitation, humidity surface water availability and wind[10]. It is important to note here that most of these fluctuations are part of the normal (natural) climatic variability, as evidenced by seasonality. Furthermore, biotic factors such as vegetation and population of host species, predators, competitors and parasites play significant roles in the distribution of vector-borne diseases. And all these are influenced by fluctuation of climatic variables[10]. Against this backdrop, the current climate change scenario is expected to cause widespread shift in the pattern of a number of infectious diseases and alter the life cycle dynamics of vectors and parasites as well as dramatically influence the transmission potential of the vectors resulting in introduction of diseases into new areas (emergence) and or cause dramatic increase of the disease incidence in already endemic areas (re-emergence). For instance, an increase in temperature accelerates the vector's metabolic rate, which consequently affects the nutritional requirement of the vector. Under such condition, the blood-sucking vectors feed more frequently, leading to increased egg production which in turn increases the transmission potential of these vectors. WHO[10], McMichael and Bundy [14] among others, assessed the major vector-borne parasitic diseases and the likelihood of change in their distribution (emerging and re- emerging), as a result of climate change.

By this assessment and ranking, the geographical distribution of malaria is highly likely to be affected by climate change. The distribution of other diseases such as schistosomiasis, onchocerciasis, dengue and yellow fever are very likely to be affected while the distribution of lymphatic filariasis, African trypanosomiasis, American trypanosomiasis and leishmaniasis are also very likely to be affected by climate change. This study uses malaria, human trypanosomiasis, onchocerciasis and schistosomiasis to illustrate how climate change might affect the global problem of emergency of vectorborne parasitic disease.[10,14]

Temperature and rainfall:

During the twentieth century, there was a rise in average daily temperatures; during the last fifty years, surface temperatures appear to have been warmer than any similar period in the last 600 years[15]. And, because warmer air can hold more moisture than cooler air, the hydrologic cycle has changed, particularly affecting waterborne disease vectors, which are sensitive to changes in the hydrological cycles. There were also increases in cloud cover[16], total precipitation[17], and frequency in extreme precipitation events, at an intensity of more than two inches per day[18-20]. It is expected that by the year 2100, there will be a 2^0C rise in temperatures with accompanying indirect effects: a 49 cm. rise in sea level, an increase in hydrologic extremes[21] and enhanced evaporation, leading to both more droughts and more floods, and prolonged recovery of the ozone hole[21]. Extreme weather has deleterious effects on the population: drought resulting in poor hygiene and reduced food supplies, floods in contamination. Although global distributions of these changes are expected to be unequal, they are expected to result in significant wide ranging effect on ecosystems[22]. As global warming continues, there is concern for increased transmission of same tropical diseases and potential or their expansion (of debatable extent) into temperate regions[23]. For example, temperature determines the rate at which mosquitoes develop into adults, the frequency of their blood feeding, the rate with which parasites are acquired and, the incubation time of the parasite within the mosquito.

These influences must be compared with the opposing effects that high temperatures exert in reducing adult mosquito survival. Altitude can serve as a proxy for temperature; the average temperature decrease with height is 100 m in free atmosphere[24]. Recent mathematical simulations, using, as an example, the minimum temperatures of approximately 1^0 and 15^0C for the development of the malaria parasites, *Plasmodium falciparum* and *P.vivax*, respectively, calculated the altitudes (which vary by latitude) at which these temperatures occur. With a threshold temperature of greater than 20^0C required to spark an epidemic[25], areas in Africa above 1000-1500 m are considered safe from the spread of malaria. Rainfall intensity is considered a key determinant of the transport of pathogenic micro-organisms, including parasites. During periods of heavy rainfall or melting snow, when the capacity of a sewer system and/or treatment plant can be overwhelmed, the excess wastewater may be discharged directly into surface water bodies[25,26].

The length of rainy and dry seasons and the interval between seasons affects larvae and adult vector development and abundance. Transmission of many parasitic diseases is confined to the rainy season. Rain provides the breeding sites for mosquitoes and helps create a humid environment, which prolongs the life of vectors. The distribution of snails and their *Schistosoma* parasite species are also sensitive to the amount of rainfall and length of the dry season. With an annual rainfall of 2.5 m or less, *S. japonicum* is present only in very wet regions with short dry seasons, *S. haematobium* in very dry regions with long dry seasons and, *S. mansoni* in regions of medium rainfall and medium-length dry seasons[27].

El Niño Phenomenon:

The El Niño phenomenon, cycling with a frequency of every 2-7 years, is second only to seasonal variability as the strongest driver of weather variability in many regions of the world[28]. During El Niño, weakening of easterly trade winds causes warm equatorial Pacific water to migrate from the western to the eastern Pacific, resulting in drought in some regions of the world and flooding in others. For instance, in the East African highlands, El Niño results in excessive rainfall and in southern Africa, drought[28]. Surveillance systems need to be developed in order to identify association between climatic phenomena and locally appropriate indicators of outbreaks of parasitic disease, such as malaria[29-30].

Conclusions

It is evident that parasitic diseases may be listed among the infectious diseases to which special attention should be paid because of climate change in the future. As is the case for other infectious diseases, all evidence indicates that the effects of climate change on parasites are more patent in temperate and colder northern latitudes as well as in high altitude areas, where modifications of climate variables appear to be more pronounced. First temperature and second the water-related variables are the meteorological factors that have been more frequently linked to the impact of climate change on parasites.

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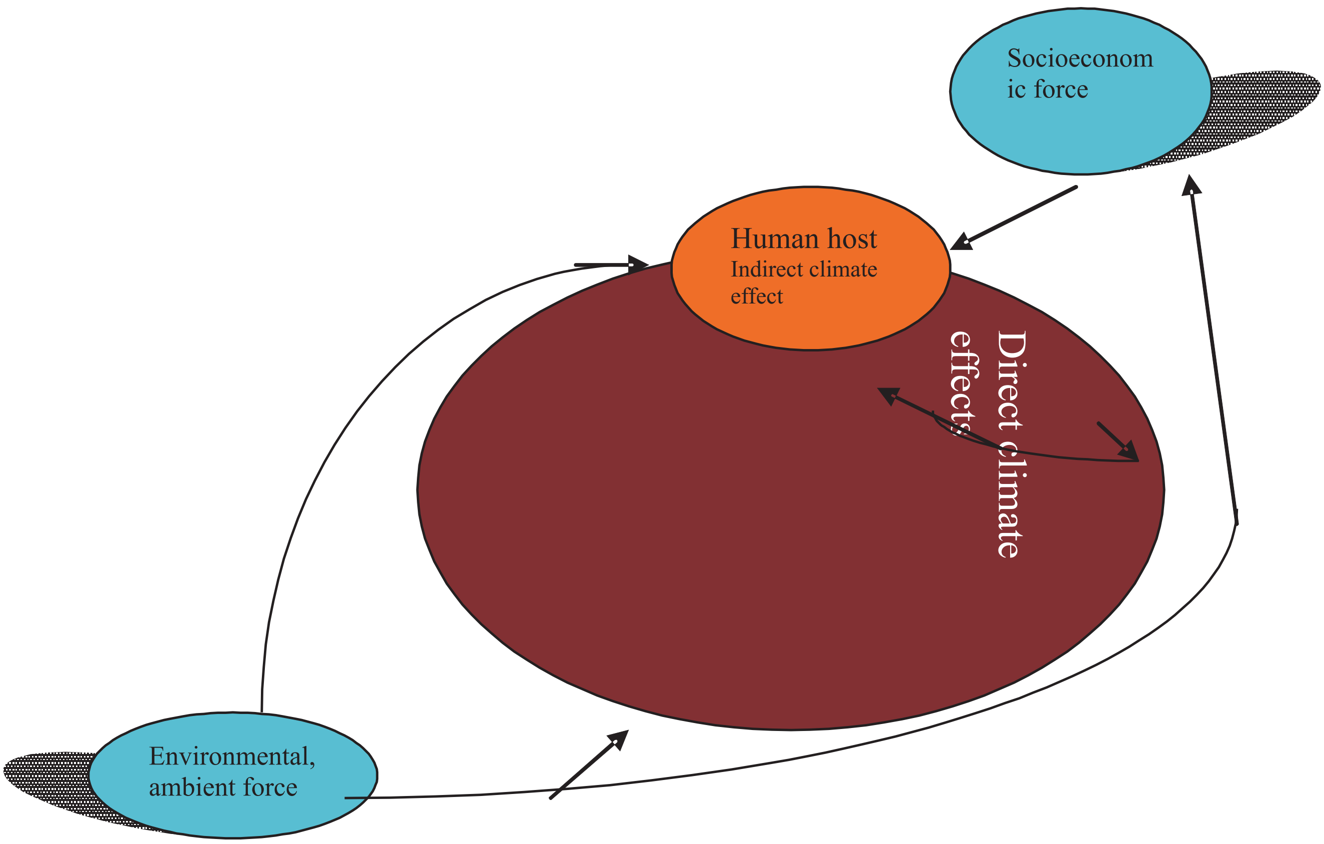

Figure 1
Direct and indirect effects of climate on humans