Oriental Journal of Chemistry Vol. **26**(2), 617-622 (2010)

Climate change impacts on vector-borne infectious diseases (A Review)

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(Received: January 12, 2010; Accepted: February 19, 2010)

Climate change is an occurring phenomenon that creates extreme weather patterns and global warming. These extreme weather patterns and global warming have a direct negative impact on infectious diseases, especially vector-borne infectious diseases. Malaria is one of the vector-borne infectious diseases that are particularly affected by climate change as it is extremely sensitive to meteorological conditions. This extreme sensitivity is creating a resurgence and redistribution of the malaria vector, the mosquito. This resurgence and redistribution of the mosquito puts an extra pressure on the public health system, especially the public health infrastructure of a developing country. An integrated framework assessment is needed for the public sector to determine the risks of climate change on infectious diseases. Infectious disease may not have affected most developed countries as they have their impact on developing countries, but with climate change this dynamics is rapidly shifting and must be addressed. The key to the integrated framework assessment is the understanding that infectious diseases have multiple determinants that are not just biological, but ecological, sociological, and epidemiological. This paper assesses the climate change impacts on vector-borne infectious diseases. A framework is necessary for the public health sector to determine the risks of epidemics in different demographics and geographic regions. Malaria is an interesting vector-borne disease as it brings up the issue of developing countries versus developed countries.

Key words: Global warming, Vector-borne infectious diseases, malaria, public health and framework.

INTRODUCTION

Climate is "the average weather, described in terms of the mean and other statistical quantities that measure the variability over a period of time and possibly over a certain geographical region"(1). Within the 20th century, the cooling trend of the last 1,000 years has been reversed due to greenhouse gases being trapped in the atmosphere and the average temperature has risen by 1°C(2). In fact, the amount of carbon dioxide has always been between 180 to 280 ppm in the atmosphere, but today it is 336 ppm, surpassing the rates observed in the ice core records. As a result of climate change, global warming is taking place, which happens to occur twice as fast during the night-time in winter and at high latitudes in the winter; also the oceans are warming up to 3km down(3,2). Global warming, in turn, is increasing the occurrence of extreme weather events; this combination of weather instability and warming is making an impact on infectious diseases, namely their vectors and hosts.

Climate is a key determinant of health;" and climate constrains the range of infectious disease, while weather affects the timing and intensity of outbreaks" (4,5,7). The World Health Organization has reported that since 1975 over 30 new diseases have appeared including AIDS, Ebola, Lyme disease, Legionnaire's disease, toxic Escherichia coli, a new hantavirus, and a rash of rapidly evolving antibiotic-resistant organisms. In addition, there has been a resurgence of old diseases such as malaria and cholera. Of course, a resurgence and redistribution of infectious diseases is partly due to the deterioration of the public health system, but infectious diseases that involve two or more species, such as malaria (humans and mosquitoes), "reflect changing ecological and climatic conditions as well as social changes"[2,6,8].

Infectious diseases

There are two categories of infectious diseases based on the mode of transmission: directly spread infectious diseases, meaning person to person, or indirectly spread infectious diseases through either vector organisms, such as mosquitoes and ticks, or non-biological vehicles, such as water and soil [9,11,17]. There are three great transmissions between humans and microbes that are recognized. The first being early human settlements that enabled enzootic species to enter the human species. The second being the early Eurasian civilization that came into contact through military and commercial endeavors about 2000 years ago, spreading dominant infections. Finally, the third great transmission involved European expansionism over the past five centuries that caused a transoceanic spread of infectious diseases[4,7,18,12]. There is a very limited climate range for vector species regulated by precipitation, sea level, wind, and sunlight[4,1,13]. Changes in the prevalence of infectious diseases are "mediated through biological, ecological, sociological, and epidemiological processes". And thus there is a multitude of ever changing disease determinants[1,16,3,22].

Mosquito Vectors and Range Expansion

The range and transmission of mosquitoes has been affected by global warming, mostly in developing countries. So far the U.S. has not seen much public health affects from climate change, but this will change if global warming continues as predicted. Diseases like malaria that are no longer seen in Europe and the U.S. could possibly migrate further north and create huge epidemics. If the public health infrastructure does not anticipate the effects of climate change on infectious diseases, millions of people could die. Climate change is a global issue and must be dealt with before things go wrong.

"Diseases carried by mosquito vectors are particularly sensitive to meteorological conditions". So "temperature thresholds the geographic range of mosquitoes;" an example being that extreme heat kills mosquitoes, warmer temperatures, within their survival range, increases their reproduction rate, biting activity, and the rate at which pathogens mature within them [1,23,12]. *Anopheles* mosquitoes are the carriers of malaria and its life span is only few weeks, the transmission of malaria takes place when temperatures exceed 16 °C (2,3,4). This extreme sensitivity to seasonal patterns explains how rainfall can increase the number of mosquito breeding sites, while dry periods can eliminate these breeding sites, but at the same create new habitats for mosquitoes[1,3,4,24,25,26].

It is predicted that global warming will increase the area of malaria transmission from 45% of the world's population to 60%. For example, *Anopheles* mosquitoes used to be found in North America, but by the 1980s were restricted to California, however, since the 1990s small outbreaks occurred in Texas, Georgia, Florida Michigan, New Jersey, New York, and Toronto during extreme hot conditions weather. Since the planet's average temperature has increased by 1ÚC, plants, insects, and insect-borne diseases are migrating to higher elevations[3,31,37]. In fact, the word malaria comes from European colonists who settled in the highlands of Africa in the 19th century fleeing from lowlands that were known as 'mal arias' [2,3,36,37].

Disease Determinants

There is a wide disparity between the developing world and the developed world in regards to the incidence of diseases; 40% of the population in the developing world and only 2% of the developed world is infected with at least one infectious disease (1,33,29). This disparity between the developing and developed world is mainly due to socioeconomic conditions, though the gap might become narrower with climate change[1,36]. However, developed countries are able to afford public health programs to protect themselves from an epidemic. There are a massive amount of disease determinants that are ever changing due to the "complexity of many indirect feedback interactions or mechanisms" on climate change. For example, one can improve socioeconomic levels, by reducing the breeding sites for mosquitoes, but this can also cause deforestation and in turn an increase in the contact between humans and mosquitoes[1,37]. Also higher temperatures could increase or reduce the survival rate of mosquitoes; it all depends on their ecology behavior, and many other factors[1,3,35].

Integrated Framework

Climate change not only brings ecological changes such as an alteration in the range and abundance of a species, but also biological and social changes. This, in turn, impacts epidemiological outcomes, such as mortality and morbidity rates. And so this combination between the ecological, sociological, epidemiological, and biological is the best way to create an "integrated assessment framework for evaluating research on the association between climate change and infectious diseases" [1,37]. Ecological changes include biodiversity loss, community relocation, and nutrient cycle changes; sociological changes include migration, nutrition, sanitation, and population; epidemiological changes include host physiology, and disease morbidity and mortality; and finally changes in transmission biology include vector dynamics and pathogen dynamics (Fig.). The above links between climate change and infectious diseases clearly indicates a multitude of disease determinants, making it difficult to study. Thus, there hasn't been much research on the subject and most of the research found is on transmission biology and not on ecological and sociological factors[1,12,31]. Studies on ecological changes and infectious

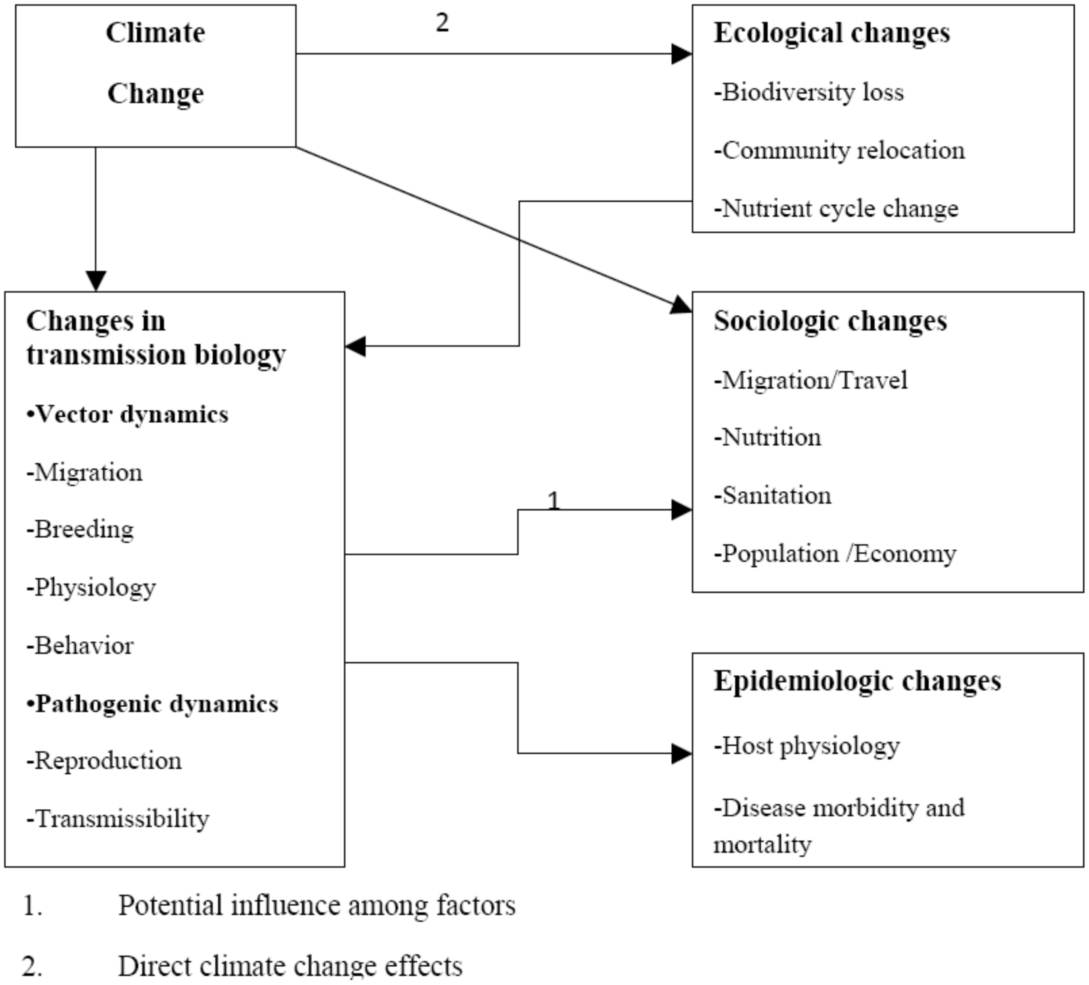

Fig. 1: Integrated assessment framework for evaluating research on the association between climate change and infectious diseases

diseases discuss habitat destruction, while studies on sociological changes and infectious diseases focus on economic developments, such as nutrition and sanitation[34,1,17]. The integrated assessment framework: means by which cross-disciplinary research could be integrated to identify, target, and initiate investigation in a number of areas, including: systematic understanding of ecologic and epidemiologic responses to climate changes; potential effects of climate changes on food and water supplies; effects of resource availability on human demographic changes (e.g., migration, urbanization), and vice versa; confounding effects of travel, habitat loss and pollution; potentially mitigating effects of increasing wealth, sanitation, nutrition, and disease control, or divergence in standards of these among human populations; effects of human activities on ecosystems; and urbanization and patchy or heterogeneous dynamic

CONCLUSIONS

The impact of climate change impact is ecological, biological, epidemiological, and sociological on which human life depends, but the degree of this impact is not known, because the variables are interrelated and numerous. There is also a huge dependence on a strong public health system to adapt to the changing risks of vector-borne diseases. The developing countries with a poor public health system are at a higher risk to health problems that are intensified by climate change; this was also found to be the case within poor populations in the United States. Consequently a dialogue must take place between developing and developed countries with regards to climate change and its impacts on health risks.

Human activities are altering atmospheric chemistry and changing the earth's heat budget. Together, these chemical and physical changes compounded by large scale land use and land-cover changes have begun to affect biological systems. The public and policy makers must be increasingly concerned with the biological consequences and society costs associated with climate change .The key to combating the issue of climate change and infectious diseases is to recognize the circular connections between the vector and the biological, ecological, epidemiological, and sociological changes.

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