

## A Problem of Climate Change as Seen by a Pharmaceutical Researcher

# The Emerging and Forecasted Effect of Climate Change on Human Health

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Global warming is an unequivocal phenomenon today. Climate change including global warming has various effects on human health. The direct effects include increase in cases of heat-stroke and in mortality rate among those who have cardiovascular and and/or respiratory diseases. The main indirect effects are on infectious diseases. Vector-borne and water-borne infectious diseases are two main categories of infectious diseases that are forecasted to be most affected. There will be an increase in the number of vector-borne infections via expansion of the arthropod-infested areas, and increase in feeding behavior of infected mosquitoes. There will be increase in the number of cases with water-borne diarrhea diseases. It should, however, be noted that the levels of the impacts of climate change on human health will differ among regions, depending on factors such as social infrastructures, foreign trade and trip, age distribution, *etc.* Thus, the effects on health should be elucidated for each of the regions of the world. The studies of the effect of climate change on human health have been progressed in recent years; however, current understanding of the effect of climate change on human health including infectious diseases is not sufficient. Further studies are needed to understand in detail the effect of climate change on human health.

**Key words**—— climate change, global warming, vector-borne infectious disease, water-borne diarrhea, heat-shock

## INTRODUCTION

Climate change including global warming is an unequivocal phenomenon today. Climate change has various effects on human health. The emerging evidence of the effect of global warming on human health has been summarized in the 4th report of Intergovernmental Panel on Climate Change (IPCC).<sup>1)</sup> The report states that climate change has altered the distribution of some infectious disease vectors (medium confidence), altered the seasonal distribution of some allergenic pollen species (high confidence), and increased heatwave-related deaths (medium confidence). The effects on human health

can be divided into two categories; direct effect on the illness such as heat-shock and on increased mortality in population with other diseases, and indirect effect on diseases such as infectious diseases and allergy (Table 1). In this present review, the effect of climate change on human health is addressed separately focusing separately on Japan and the world.

## DIRECT EFFECT OF CLIMATE CHANGE ON HEALTH

As the direct effect of global warming, an increase in the number of heat-shock cases has been apparent. There has been a positive relationship between temperature and the number of heat-shock cases in major cities in Japan. The heat-shock cases increase sharply 32°C and higher. Based on these observation it is likely that global warming will increase the number of heat-shock patients. An increase in mortality rate will also become apparent especially among those with cardiovascular and

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**Table 1.** Some of the Emerging and Forecasted Effects of Climate Change on Infectious Diseases and Other Human Health Conditions in the World

|  |  |
|--|--|
| Direct effect on other health conditions                                 |  |
| Heatwaves:   | Short-term increase in mortality especially among those with cardiovascular and/or respiratory diseases, and increase in heat-shock patients |
| Co-effect with air pollution:  | Increase in asthma and allergy patients  |
| Storms and floods:   | Increase in morbidity and accidental death   |
| Indirect effect on infectious diseases                                   |  |
| Expansion of mosquito-infested areas, and increase in mosquito activity: | Increase in the number of patients with mosquito-borne infectious diseases ( <i>i.e.</i> dengue and malaria) and expansion of epidemic areas |
| Contamination of water and foods with bacteria:                          | Increase in the number of patients with water-borne and food-borne infectious diseases   |
| Deterioration of environmental and social conditions:                    | Increased risk of infectious diseases  |

and/or respiratory diseases.

## INDIRECT EFFECT OF CLIMATE CHANGE ON INFECTIOUS DISEASES

There is an indirect effect of climate change/global warming on health. The major indirect effect is on infectious diseases. Among infectious diseases, vector-borne and water-borne infectious diseases are two main categories which are forecasted to be most affected.

### EFFECT OF CLIMATE CHANGE ON INFECTIOUS DISEASES

#### Effect That Has Become Apparent in the World Effect of Climate Change on Vector-borne Infectious Diseases

Vector-borne infectious diseases are caused by the pathogens transmitted by arthropods. Mosquitoes and ticks are the main vectors. It has been reported that global warming affects vector-borne infectious diseases via indirect effect on activities and distribution of vectors (Fig. 1). The major mosquito-borne infectious diseases include dengue fever, malaria, chikungunya fever, Japanese

encephalitis (JE), West Nile fever and yellow fever. Many reports have suggested that the vector-borne infectious diseases are heavily affected by global warming.

#### Dengue Fever

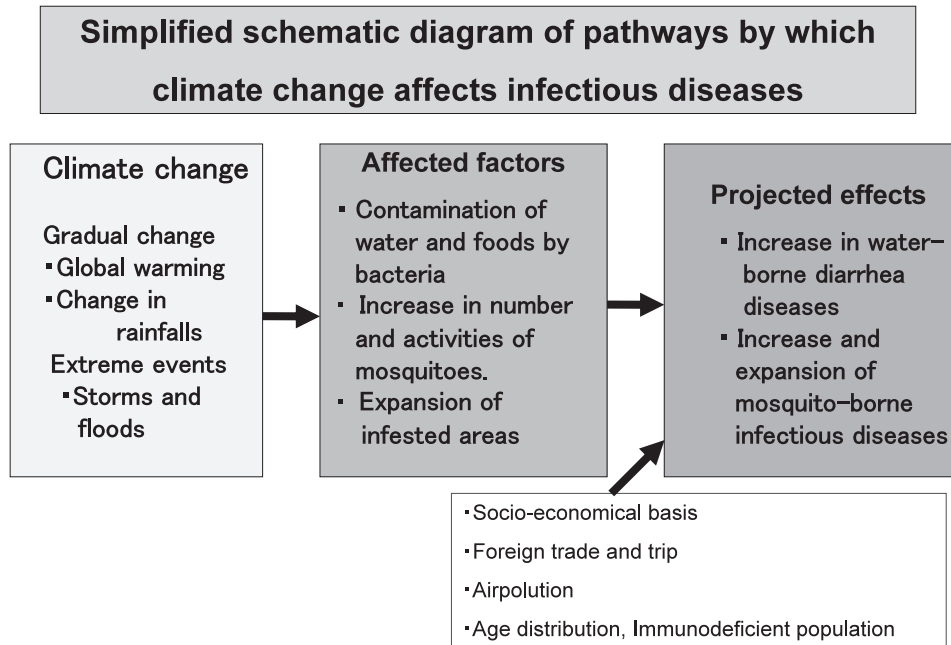
Dengue fever is an important vector-borne viral infectious disease in the world. There have been reports that suggest an association between climate change and epidemics of dengue fever.<sup>2–5)</sup> However, the absence of an association between climate change and epidemics of dengue fever has also been reported, probably due to the presence of multiple other factors in addition to climate change. The model of vector abundance demonstrated a good agreement with the distribution of reported dengue cases in some areas in the world.<sup>6)</sup> Thus, it is predicted that the positive effect of climate change on the abundance and distribution of vector mosquitoes eventually leads to increase in the number of dengue patients and expansion of dengue epidemic areas.

#### Malaria

Malaria is considered to be the most important vector-borne infectious disease in the world. It has been reported that climate change have an influence on the distribution, intensity of transmission, and seasonality of malaria in sub-Saharan Africa.<sup>7, 8)</sup> Associations were reported between inter-annual variability in temperature and malaria transmission were in Africa. The number of admission cases with malaria was associated with rainfall and high maximum temperature 3–4 months previously in Kenya.<sup>9)</sup> The study in Ethiopia indicated that epidemics were associated with high minimum temperatures in the preceding months (Abeku *et al.*).<sup>10)</sup> On the other hand, there have also been reports that suggest no clear evidence of association between climate change and malaria in South America<sup>1)</sup> or in the Russian Federation.<sup>11)</sup> Thus, there is still uncertainty about the potential impact of climate change on malaria at local levels.<sup>1)</sup>

#### Other Vector-borne Infectious Diseases

There have been reports on climate-related shifts in the distribution of tick vectors. Northern or altitudinal shifts in tick distribution have been reported in Sweden and Canada,<sup>12–14)</sup> and also altitudinal shifts in the Czech Republic.<sup>15)</sup> Severe outbreak of Murray Valley encephalitis has been reported to occur after heavy rainfall and flooding in southern Australia.<sup>16)</sup> Heavy rain or flood can



**Fig. 1.** Simplified Schematic Diagram of Pathways by which Climate Change Affects Infectious Diseases

cause outbreak of Ross River fever, due to increased breeding of mosquitoes.<sup>17)</sup> It has been reported that the number of chikungunya patients increased after draught rather than heavy rainfall. Therefore, the effects of climate change on vector-borne infectious diseases are complex, although the available data generally support the conclusion that global warming along with other climate change increases the number of patients or the distribution of the patients, via effects on the responsible vectors.

#### **Effect of Climate Change on Diarrhea Diseases by Bacteria**

It has been predicted that water-borne infectious diseases are also heavily affected by climate change. The number of cholera cases increased by both high and low rainfalls in Bangladesh.<sup>18)</sup> The number of non-cholera cases also increased by high and low rainfalls, and by higher temperature in Bangladesh.<sup>19)</sup> However, the levels of the effects depends on the infrastructure, thus, it is likely that the effect of the climate change on diarrhea diseases is much less apparent in developed countries.

#### **Effect That Has Become Apparent in Japan**

The effect of climate change on infectious diseases has not become apparent as an increase in the number of patients with vector-borne infectious diseases or diarrhea diseases in Japan. However, there

has been apparent changes in distribution of vector mosquito. *Aedes albopictus* (*A. albopictus*) is a major vector of dengue fever and chikungunya fever. The distribution of *A. albopictus* in northern Japan has been examined.<sup>20)</sup> The northern border of the habitat of *A. albopictus* was at northern Kanto district, according to the research by U.S.A. occupational force after the World War II. The northern border has been moving northward, and is at the northern Tohoku district in 2006.<sup>21)</sup> The northern border of the habitat of *A. albopictus* is well accordant with the area with annual average temperature of 11°C and higher. This does not indicate that epidemic of vector-borne infectious diseases such as dengue fever and chikungunya fever will occur in northern Japan, but suggest that the area with the risk is expanding northward.

#### **The Projected Trends in the Effect of Climate Change on Health**

##### **The Projected Trends in the World**

The projected trends of the effect of global warming on human health were summarized in the 4th report of IPCC.<sup>1)</sup> The projected trends in climate change-related effects includes: increase in malnutrition and consequent disorders (high confidence), increase in the number of people suffering from death, disease and injury from heat-waves, floods, storms, fires and droughts (high confidence),

change of habitats of some infectious disease vectors (high confidence), mixed effects on malaria; the geographical range will contract in some areas, while it will expand and the transmission season may be changed (very high confidence), increase in the burden of diarrhea diseases (medium confidence), increase in cardio-respiratory morbidity and mortality associated with ground-level ozone (high confidence), and increase in the number of people at risk of dengue (low confidence). There will be some benefits to health, including fewer deaths from cold. The benefits will be, however, outweighed by the negative effects of rising temperatures worldwide in developing countries (high confidence).

### The Projected Trends in Japan

There will be increase in the number of heat-shock cases and in increase in mortality rate among those who have cardiovascular and respiratory disorders, unless appropriate adaptation measures are taken.

As stated above, there has not been apparent effect on the number of infectious diseases in Japan. However, it is predicted that the impacts will appear in one form or another if climate change/global warming continues to progress in future. There will be further expansion of habitats of *A. albopictus*. This does not necessarily indicate the occurrence of epidemics of dengue fever and chikungunia fever, for which *A. albopictus* is one of the major vectors. Further, it is possible that activity of JE virus-infected mosquitoes, become constantly high even in northern Japan probably including Hokkaido, the northernmost island. These trends, however, will not directly increase the number of JE patients, if appropriate countermeasures such as strong implementation of JE vaccination are taken.

Different from the projected trends in the world, it is unlikely that climate changes induce re-emergence of malaria epidemics or increase in the number of patients with diarrhea diseases, unless current infrastructures are massively damaged.

### THE OTHER FACTORS TO BE CONSIDERED IN THE FUTURE STUDY

There are other important factors to be considered especially in the study on the effect of infectious diseases. The number of patients with infectious diseases can be affected by multiple factors.

There are differences in virulence among strains in each pathogen. Thus, the number of symptomatic infection can vary depending on the level of the virulence of dominant strains of the pathogen. Furthermore, the changes in the number of cases depends heavily on the accuracy of surveillance and reporting systems, which are not still established in many developing countries. Thus, in the studies of the effect of climate change on infectious diseases, multiple biological and sociological factors should be taken into account.

### CONCLUSIONS

Many studies have suggested that climate change has various negative effects on human health including infectious diseases. However, it should be noted that the levels of the impacts of climate change on human health will differ among regions, depending on various factors, such as social infrastructures, foreign trade and trip, air-polution, age distribution, *etc.*

This makes the interpretation of the results of the studies quite difficult. Understanding of the effect of climate change on human health has been progressed very much in recent years; however, it is true that much more studies and data are needed to further understand in detail the effect of climate change.

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