Chapter III

FEATURES OF CLIMATE AND ECOLOGICAL CHANGE THAT INCREASE THE RISK OF INFECTIOUS DISEASES

Building upon the discussions regarding global climate and ecological changes, the focus of the meeting now shifted to some of the features of climate and other ecological changes that increase the human risk for infectious diseases. Included in this discussion were factors related to temperature, water, spatial, temporal (seasonal), habitat and genetic changes.

Figure 10: IPCC 4th Assessment.
Adapted from Figure SPM.2 (IPCC, 2007). Illustrative examples of global impacts projected for climate changes (and sea level and atmospheric carbon dioxide where relevant) associated with different amounts of increase in global average surface temperature in the 21st century [T20.8]. The black lines link impacts, dotted arrows indicate impacts continuing with increasing temperature. Entries are placed so that the left-hand side of the text indicates the approximate onset of a given impact. Adaptation to climate change is not included in these estimations. All entries are from published studies recorded in the chapters of the Assessment. Confidence levels for all statements are high.

At the meeting, it was reiterated that climate and ecological factors are part of a broad spectrum of determinants of disease (see Figure 11), all of which interact. Even now, we are beginning to see the effect that global warming has on infectious diseases.

35 Adapted from presentations by Jonathan Patz and Bettina Menne.
Figure 11: Convergence model for the emergence of infectious diseases\textsuperscript{37}.

Figure 12 describes the cluster of factors that influences the changing disease burden caused by Lyme disease.

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\textbf{Factors influencing vector and reservoir animal abundance:}
- Land use and land cover changes (the latter due to human activities or from natural causes) that affect tick habitats and host animal populations.
- Global changes, such as climate change, with direct effects on the survival and development of ticks, and indirect effects on tick abundance and pathogen transmission through impacts on the composition of plant and animal species, and on the on-set and length of the seasonal activity periods of the tick.

\textbf{Factors influencing human–tick encounters:}
- Changes in human settlements and other demographic changes in relation to the proximity to risk areas.
- Changes in human recreational behaviour, including changes caused by altered climatic conditions.
- Changes in use of areas for commercial purpose, e.g. forestry, game-keeping, hunting and eco-tourism.
- Effectiveness of information campaigns on LB disease risk, and the use of different self-protective methods.

\textbf{Factors affecting society’s adaptive capability to changes:}
- Socioeconomic and technological level.
- Presence of monitoring and surveillance centres and networks.
- Capability of the public health sector and local communities to handle acute and long-term changes in disease outbreaks and risk.
- Type of energy and transportation systems in use and other factors influencing the society’s contribution to present and future greenhouse gas emissions.

\textsuperscript{37} US National Academy of Sciences, Institute of Medicine. From a presentation by Jonathan Patz.
Additionally, it was noted that ecological changes result not only from climate change but also from other environmental causes. These other environmental change factors include land use change as a result of deforestation, mining, or water projects. Some argue that the speed of land use change affects local climate conditions much more rapidly than global warming. However, other issues arise when habitat and biodiversity are changed. Environmental and climate change are important, but changing land use is happening even faster. An area of rainforest the size of Germany is being deforested every year.

Figure 13: Health effects of climate change.

The key physical attributes of climate change (rising temperatures, sea-level rise and extremes of the water cycle) cut across many health areas (see Figure 14).
A WHO quantitative assessment that took into account only a subset of the possible health impacts, concluded that the effects of the climate change that has occurred since the mid-1970s may have caused over 150 000 deaths worldwide in 2000 alone\(^2\).

**General impact on vectors and infectious agents**

**Temperature**

Mosquitoes are cold-blooded, and air temperature determines their body temperature. When we talk about adapting to increasing temperatures, it must be kept in mind that there is a big difference between warm-blooded mammals and mosquitoes, where a fraction of a degree can change ecology and transmission dynamics.

The following map of Zimbabwe, for example, shows how high altitude areas have a very low incidence of malaria, but with lower altitudes, average temperatures and malaria increase.

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Figure 15: Relationship between malaria and altitude, Zimbabwe\(^{43}\).
Altitude is a good surrogate for temperature: the average temperatures decrease with altitude = 6 °C per 1000 meters.

Climate is not the only relevant issue when it comes to infectious diseases. Drug resistance, nutrition status and all sorts of others factors come into play. But there is also a climate envelope. The parasite that causes malaria cannot develop unless the temperature is above 16–18 °C, depending on the species. This is why malaria is a tropical disease. It cannot develop below a certain temperature, and the warmer the temperature, the faster the parasite develops. Other factors such as mosquito survival also come into play.

For smaller countries like Honduras, Nicaragua and Thailand, predictions based on a climate-driven mosquito (aedes) index model compare very well to the actual number of nationally reported cases. For larger countries like Brazil, with several distinct climate zones, there is not much correlation.

Figure 16: Dengue fever\textsuperscript{44}. Aedes mosquito index (climate-based model) compared to nationally reported dengue cases. Hopp M, Foley J. 2003.

As far as diseases relevant to Europe are concerned, West Nile virus (see Box 8) appears to be influenced by extreme climate, especially hot temperatures, and drought conditions. The \textit{culex} mosquito, which spreads the virus, thrives in droughts and dirty urban water. In recent large outbreaks of West Nile virus in Romania, the Russian Federation, Israel and the United States of America, the outbreaks were always associated with either a drought or a heatwave.

\textsuperscript{44} Source: Presentation by Jonathan Patz.
Hydrological factors

As noted in the WNV example given above, hydrological extremes\textsuperscript{46}, in addition to temperatures, play an important role. A study looking at extreme precipitation related to water-borne diseases for all reported outbreaks in the US from 1948–1994 (excluding outbreaks with known engineering failures) found that 67\% of water-borne disease outbreaks were preceded by extremely heavy rainfall in the upper eightieth percentile\textsuperscript{47}. A correlation between this and combined sewage overflow events has been made\textsuperscript{48}. Lack of fresh water is associated with a variety of challenges to sustainable development.

\textsuperscript{45} Hubálek Z, Kriz B, Menne B. 2006; p. 218. From Bettina Menne's presentation.

\textsuperscript{46} There is some indication that epidemics of WNF and ecologically similar St. Louis encephalitis in North America occur often after long, dry summers, followed by one wet summer (Epstein P. 2001). The data, however, are insufficient at present.

\textsuperscript{47} Presented by Jonathan Patz.

**Habitat fragmentation and biodiversity**

Land use change is taking place all over the world, and habitat fragmentation changes species biodiversity, which in turn can affect health. A look at a study on Lyme disease demonstrates how this may occur. If white-footed mice are the only reservoir host, 80% of ticks will be carrying the bacteria that cause Lyme disease. However, with a lot of biodiversity there are several other hosts for ticks that are less than ideal carriers for Lyme bacteria. Therefore, the risk of Lyme disease is lower, with maybe only 30% of all ticks carrying the Lyme disease bacteria.

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50 Rick Ostfeld (Institute for Ecosystems Studies), cited by Jonathan Patz in his presentation.
Deforestation

A study in the Peruvian Amazon comparing pristine jungle with disturbed areas\(^{52}\) observed major differences in the number of mosquito \((Anopheles darlingii)\) larvae. In the disturbed areas, researchers counted six or seven times as many larvae, implying that deforestation increased the risk of malaria infections.

Seasonality

In Europe, pollen season now lasts longer. On average, it has increased by 10–11 days over the last 30 years (Menzel A, Estrella N, Fabian P. 2001). The introduction of new invasive plant species with highly allergenic pollen, in particular ragweed \((Ambrosia artemisiaefolia)\), presents significant risks to human health.

Many food- and water-borne diseases show strong seasonal patterns that reflect their mode of transmission. Ambient seasonal temperature changes have been estimated as drivers in approximately 30% of reported Salmonellosis cases in ten European countries, with a 5–10% rise in Salmonella infection incidence for each 1 °C increase in weekly temperatures above 5 °C (WHO 2005, p24).

Spatial changes

These temperature, hydrological and other changes have resulted in the spread of infectious agents into new areas. For example, \(Ixodes ricinus\) has been observed in higher latitudes and altitudes over the last 50 years (see Figure 20). With regard to leishmaniasis, new endemic areas have been detected (WHO 2005, p 22).

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\(^{51}\) Source: Schmidt KA, Ostfeld RS. 2001. From a presentation by Jonathan Patz.

\(^{52}\) Jonathan Patz with Amy Vittor.
Also affecting spatial distribution are changes in bird migration, travel and transport. The effects of these factors on the spread of SARS and Avian Flu have been reported (http://www.newscientist.com/channel/health/bird-flu). Invasion of exotic species, like ragweed, has been noted in new areas. Northward movement of some cyanobacteria has also been reported (http://www.int-res.com/articles/meps/211/m211p193.pdf) (see Figure 21). Attribution is a key challenge here.

**Figure 20: Movement of Ixodes ricinus in Scandinavia**

**Figure 21: Approximate distribution of visceral leishmaniasis (dark, southern region) and its sandfly vector (light, smaller area) in Europe.**

**Genetic shifts**

Genetic shifts have also been noted in response to global warming. Bradshaw and Holzapfel (2001) noted shifts in a number of behaviours and seasonality.

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54 Adapted from Lindgren E, Naucke T, Marty P, Menne B. 2006; p. 134. From a presentation by Bettina Menne.
Genetic shift in photoperiodic response correlated with global warming

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To date, all altered patterns of seasonal interactions observed in insects, birds, amphibians, and plants associated with global warming during the latter half of the 20th century are explicable as variable expressions of plastic phenotypes. Over the last 30 years, the genetically controlled photoperiodic response of the pitcher-plant mosquito, Wyeomyia smithii, has shifted toward shorter, more southern daylengths as growing seasons have become longer. This shift is detectable over a time interval as short as 5 years. Faster evolutionary response has occurred in northern pop-

Figure 22: Genetic shifts55.

55 Adapted from Bradshaw WE, Holzapfel CM. 2001. From presentation by Bettina Menne.