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Climate and health

Climate change, presumably caused by humans, has been observed during the past decade. The change may have health effects due to an increase in radiation through the atmosphere, a change in the spread of infectious diseases, a shortage of food and clean water, and natural disasters. The mechanisms that cause climate change and the health consequences of the change are without doubt extremely complicated and difficult to understand, and the outlook is uncertain. Only large-scale international initiatives can affect the process. The development will pose a challenge to the health service at both local and international level.

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Climate is governed by the interaction between the sea, the atmosphere, ice, continents and living organisms. A change in one component can alter the balance in the system. Many organisms are dependent on certain climatic conditions, such as precipitation and temperature. Climate change will thus inevitably alter the living conditions of many pathogenic organisms, and will be of considerable epidemiological interest.

The ozone effect

UVB radiation that passes through the ozone layer has a direct effect on the DNA molecule and is therefore harmful to many biological systems. The medical effect of ozone breakdown is indirect and occurs via over-exposure to UVB radiation. This can rise by 1.5–2 % and can increase the incidence of skin cancer, both of malignant melanomas and of basal cell and squamous cell carcinoma (1, 2), as well as ordinary sunburn (2). Exposure to UVB rays, which are absorbed by both the cornea and the lens, also enhances the risk of cataracts, conjunctivitis, keratitis and damage to the retina (2–6).

In addition it has been proved that UV radiation can harm the immune system (7). The biological effect of the increase in UVB radiation will be strongest at the equator and will diminish towards the poles. UV radiation can also cause direct damage to grain crops (8).

Spread of infectious diseases

Parasites and vectors are dependent on climatic conditions such as temperature and precipitation for transmission and reproduction. Changes in these conditions due to global warming will undoubtedly cause them to increase in marginal areas and to spread to new ones (8–12). Insects are the vectors for most tropical diseases – first and foremost various species of mosquito. These flourish in warm, damp regions.

Climate change can also lead to certain parasites adopting a new host – in some cases human beings. The malaria mosquito *Aedes anopheles* may spread to higher regions (13, 14) and northwards – for example to Italy (9). The same could happen with the mosquito species *Aedes albopictus* and *Aedes aegypti*, the vectors for yellow fever and dengue fever. An increase in temperature within certain limits will promote and accelerate the development of larvae, while extreme precipitation could wash away the malaria larva. A high degree of urbanisation and pollution may cause problems with the hatching of larva and thus counteract the spreading, as could a rise in temperature that results in drought. Heat can shorten the lifetime of the mosquito and damage the parasite's living conditions, which in some areas may lead to the extinction of certain parasites. Malaria was previously endemic in Europe.

Schistosomiasis, which affects 30 % of the population in the areas where it occurs, may also spread to temperate regions, both northwards and southwards. Currently the problem of schistosomiasis is almost as serious as that of malaria. The outlook is uncertain for the relatively rare tropical diseases of onchocerciasis, filariasis, trypanosomiasis and leishmaniasis. All of these have insects as vectors. Today, leishmaniasis is endemic in Mediterranean countries; its vector is a sand fly, and the disease may spread northwards (9, 14). Deforestation and cultivation have led to an increased incidence of this disease.

Human beings have assumed the role of host on the disappearance of the previous host as a result of deforestation. Insects (for example the mosquito species *Aedes albopictus* and the tick) are also vectors for many types of viral encephalitis (14). The tick *Ixodes ricinus*, which is also a vector for Lyme borreliosis, is dependent on climatic conditions and thrives in a warm, damp climate. However, it is also dependent on deer (14).

Access to clean fresh water

One third of food production is currently dependent on irrigation, which in some countries consumes the bulk of the available water. A change in the precipitation pattern resulting from climate change may increase the total precipitation by approximately 10 %, while large volumes of precipitation will be redistributed from tropical and temperate regions to the northern and southern hemisphere and will aggravate the situation in marginal regions (9, 12). The problem of clean water will undoubtedly be greatest in Africa and India. Around one billion people do not have safe access to clean water (14). The melting of glaciers in Asia and South America may lead to a shortage of water in the summer (12).

If the sea level rises half a metre, major problems may arise with the seeping of salt into the groundwater and the loss of agricultural land (13). Half the global population lives less than 60 km from the sea and may be highly vulnerable to floods. Extreme precipitation and floods increase the risk of polluted drinking water (11) and of cholera, hepatitis and leptospirosis. Pollution from chemical fertilisers, particularly phosphates and pesticides, in combination with the warming process can encourage algal blooms in reservoirs and reduce the water quality. Blue-green algae in particular can contain toxins that are harmful to health (15).

Food production

This problem is connected to the one described above. The UN's Food and Agriculture Organization (FAO) estimates that approximately 800 million people are

Photo, Colourbox

undernourished (14). Climate change can exacerbate the problem of such undernourishment and malnutrition (11). In this context food production is the production of grain and soya beans. Under the present climatic conditions it will be possible to double corn production by 2060 by new cultivation, irrigation and improved agricultural technology, with the increase being most noticeable in developing countries. Climate change may substantially affect the outlook. According to current reports (9, 16), this subject is extremely complex. Growth is dependent on uncertain factors such as the development of the economy and of agricultural technology.

There are undoubtedly large regional distinctions. In temperate zones, climate change may have a positive effect, for example on grain production which may spread northwards (8, 9, 13, 17) and increase by up to 10 %. In addition, a rise in CO_2 content may promote photosynthesis and thereby the growth of certain types of grain (wheat, and within certain limits also maize) and soya beans.

In tropical regions where agricultural conditions are difficult, the situation may be further aggravated by drought (14). According to all models, conditions in central and southern parts of Africa will deteriorate since the net effect will be negative (9, 14). The introduction of new and better grain types and new agricultural methods may counteract the problem. The issue of nutrition is naturally related to population growth, which can also affect climate development. There may also be a need to increase redistribution – for example redistributing grain from wealthy countries to developing countries.

Global warming may cause algal blooms, an extremely relevant global problem. In addition to reducing oxygen content, this will lead to epidemics of food poisoning from shellfish and other sources. Algal toxins may cause the mass death of fish and other species, and the warming of the oceans may provide better conditions for the growth and spread of, for instance, cholera bacteria which can spread via sea water (9, 13, 14, 18). These bacteria can survive and reproduce in plankton.

Global warming can also affect ocean currents and the frequency of natural phenomena such as El Niño in the Pacific. El Niño in turn is associated with a greater prevalence of malaria and cholera (17). Many species of fish are dependent on temperature: ocean warming may result in plankton and fish species, such as cod in the Barents Sea, moving north to colder regions, and to a greater uptake of harmful heavy metal by fish (13).

Incidence of extreme weather

Some scenarios indicate that climate change may increase the frequency of heatwaves, drought, floods and hurricanes (8, 9, 14, 19). This tendency has already been noted and may have considerable medical, social, economic and political consequences. Such phenomena may become more intense (11–13, 17), and may cause harm to health and loss of human life (18). In 2003 15,000 people died in France from intense heat (11), with the old and weak most affected. The incidence of diseases that are related to extreme cold may diminish (13, 17). Extreme weather conditions such as floods and hurricanes may result in epidemics of the hantavirus and leptospirosis (14).

Consequences for Norway

The average temperature in Norway is 6.5 °C at 60° N (Bergen and Oslo), and 0 °C in Tromsø. Accepted models predict that over the next hundred years the average temperature may rise by 2–3 °C and preci-

pitation by 1–2 mm per day. The consequences will be positive – particularly for agriculture. There will be a good margin for all tropical diseases, as is the case today. Skin cancer is already a significant problem, and will probably be exacerbated due to greater exposure to the sun. This also applies to algal blooms in the sea, which will be accompanied by food poisoning – primarily from mussels. Borreliosis has become an increasing problem and will spread northwards, as has been shown in Sweden (13, 14). The incidence of the parasite disease cercarial dermatitis may increase, as was indicated in an article in this journal in 1997 (20). Apart from the above, there are no grounds to fear that an estimated global warming of 1–2 °C will have appreciable consequences for the state of health in Norway.

Relevant measures

Climate change will create both winners and losers (9, 19). The situation in poor countries with marginal conditions for agriculture and extensive problems due to tropical diseases may worsen, making these countries the losers. Rich and industrialised countries – which have presumably caused the problem by squandering energy – may well make a profit in certain areas.

It will be difficult to implement international political measures to curb the development without a fundamental change of priorities and attitude. The use of fossil fuels must be reduced along with a greater investment in renewable energy. Measures such as higher petrol tax and subsidising environmentally-friendly alternatives are unpopular but will no doubt become necessary. These may produce positive health effects – for example through greater use of bicycles etc. Further investment in alternative energy sources such as solar and wind power, geothermal heating and biomass fuel will become relevant.

Far stricter restrictions than those laid down in the Kyoto protocol are required to enable the implementation of genuinely helpful measures (17). However, political willingness to propose and carry out such measures is non-existent (21).

One positive result of a potential spread of parasites to industrialised countries may be an awakening of interest in tropical diseases. Greater resources will then undoubtedly be used to solve these problems, which so far have been given low priority.

Conflicts of interest given: None

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