Germany, Lithuania, or Norway. Spain reported 208 outbreaks, Malta 162, and Sweden 53. These differences probably reflect differences in the detection, investigation, and reporting of outbreaks rather than the actual frequency.

Long term prospects

Although some progress has been made over the past decade, coordinated efforts are still needed to ensure that Europe's population is supplied with clean drinking water and has access to safe water for recreational activities. The aquatic environment must also be maintained in terms of its chemical and biological quality. One particular problem that has been experienced in gaining access to the chain of information on the monitoring, analysis, and reporting of data that exists in virtually every country is the need to improve the reliability and comparability of data that are being produced to support the assessment and development of water policies. This is being tackled by the European Environment Agency and other international bodies, and until a pan-European reporting network is in place there will remain doubt and confusion.

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Climate change and human health in Europe

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Evidence that our world is warming has become stronger in recent years. Scientists have now confirmed that these changes are due to human activities.[1] This century the average annual temperature in most of Europe has increased by about 0.8°C.[2] Warming has been particularly great during the past two decades and in the middle to high latitudes (fig 1). In the Alps, temperature increases have exceeded 1°C above the long term mean. Northern Europe has become wetter, but a region encompassing the Mediterranean and central Europe has become significantly drier.[2] Scientists of the Intergovernmental Panel on Climate Change forecast a 1°C-3.5°C increase in average global temperature by 2100.[1] Although there is considerable uncertainty in forecasting regional and local changes in climate in Europe, it is likely that these observed trends will continue.[2]

The potential impact of a global climate change on human health has been identified as a priority for research and action in the next century, and this will be debated at a forthcoming ministerial conference on the environment and health. Our paper reviews the state of current knowledge for the WHO European region. Climate change will not affect human health in isolation, but will do so simultaneously with other ecological and demographic changes. It should be noted that effects on other regions surrounding Europe (Africa and Asia) may be of considerable importance for the European region as well.

Summary points

Europe has experienced significant warming in recent decades, and this is likely to continue

Climate warming and changes in rainfall patterns may have significant and wide ranging impacts on health, including changes in thermal stress and in the distribution and seasonality of vectorborne diseases

An increased risk of flooding of rivers with associated effects on health is forecast in Europe

Some climate change is inevitable, and therefore societies will need to adapt to minimise any adverse effects on health and society

Monitoring of health indicators, including enhanced surveillance of diseases sensitive to climate, should be developed to detect and respond to the impacts of climate change on human health

Thermal stress and air quality

Future increases in average seasonal temperatures entail an increase in the number of heatwaves in summer and a decrease in the number of cold spells in winter, at any particular location. For example, it is anticipated that the equivalent of the UK heatwave in the summer of 1976, which occurs once every 310 years under the current climate, may occur every 5 to 6 years by 2050.[3] Heatwaves are associated with a short term increase in all cause mortality (fig 2).[4] The heatwave in July-August 1995 in London was

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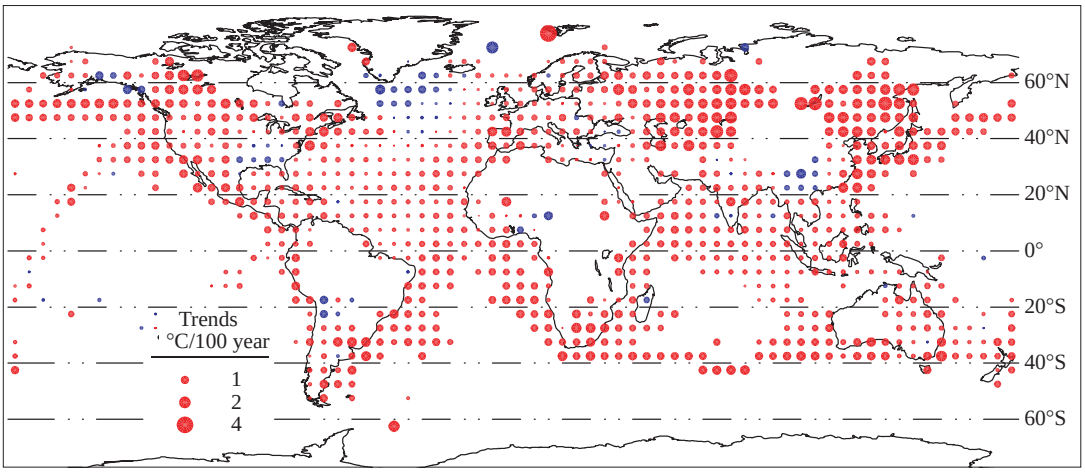

Fig 1 Observed trends in annual average temperature, 1901-96[2]

associated with a 16% increase in mortality (approximately 137 excess deaths compared with the seasonal average).[5] In 1987, a major heatwave in Athens was associated with 2000 extra deaths.[6] More research is need to determine the extent to which populations will be able to acclimatise physiologically and behaviourally to future increases in heatwaves.

A U shaped relation has been widely observed between temperature and mortality in temperate regions, so that mortality is lowest within an intermediate temperature range.[7] In European countries, many more deaths occur in winter than in summer, but it is difficult to determine the comparative contribution of cold stress and other seasonal effects. Social and behavioural adaptations to cold play an important role in preventing winter deaths in countries of high latitude.[8] A future benefit of climate change may be a reduction in excess winter mortality, particularly that from cardiovascular disease.[9 10] However, improvements in socioeconomic conditions—for example, reducing fuel poverty— may have a bigger benefit than climate warming in countries that have high rates of excess winter mortality, such as the United Kingdom.[11]

Exposures to air pollutants are generally higher during heatwaves. Large, slow moving anticyclones may cover an area for several days and give rise to conditions that readily allow pollutants (and heat) to accumulate. It is therefore difficult to predict the impact of climate change on air quality. It is, however, anticipated that climate change would entail an increase in average ambient concentrations of ozone, all other things being equal, and an increase in the frequency of episodes of ozone pollution.[12]

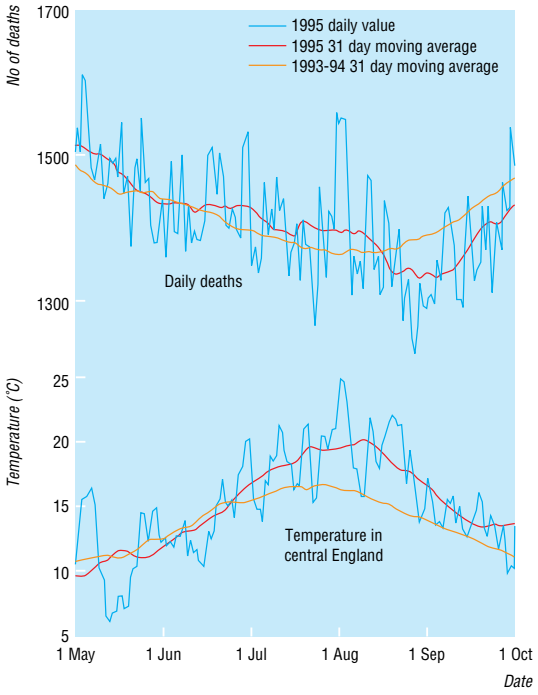

Fig 2 Mortality peak associated with a heatwave in 1995 in England and Wales[5]

Extreme events and weather disasters

An increased risk of river flooding in Europe owing to climate change is likely (fig 3).[2 13] The risk of coastal flooding will also increase unless sea defences are upgraded in response to a rise in sea level.[14] Recent river floods in central Europe left over 200 000 people homeless, and more than 100 people were killed.[15] Longer term effects on mental health have been reported after floods.[16] In Poland, for example, 50 suicides were attributed to the floods in 1997.[17] Floods may disrupt water purification and sewage disposal systems, cause toxic waste sites to overflow, and dislodge chemicals stored above ground. There may be an increased risk of communicable disease after floods, particularly from leptospirosis.[18 19]

Food and water related diseases

Climate change, warmer springs and summers, and milder winters may contribute to the current increase in incidence of gastrointestinal diseases, assuming that current trends in inappropriate food behaviour continue both from individuals and within the food industry. A UK study found a strong relation between the incidence of foodborne disease and temperature in the month preceding the illness.[20] In addition, the distribution and activity of domestic pests (for example,

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Fig 3 Floods in central Europe in 1997

flies, cockroaches, and rodents) may change in response to climatic changes.

Some populations in eastern Europe have restricted access to water in the home resulting in diseases related to poor hygiene.[21] These populations would be vulnerable to any climate related decreases in freshwater availability. The majority of countries in Europe, however, have high quality water treatment services, which must be maintained under future changes in rainfall patterns—particularly the anticipated increase in extreme rainfall events,[1] which may be associated with outbreaks of cryptosporidiosis.

Vector borne diseases

The distribution and seasonality of diseases that are transmitted by cold blooded insects or ticks are likely to be affected by climate change.[4 18] A change in the distribution of important vector species may be among the first signs of the effect of global climate change on human health.[18] Indeed, there is some evidence that the distribution of tick vectors in Sweden has expanded north between 1980 and 1994, and that this is consistent with observed changes in climate.[22]

Three countries in the WHO European region—Azerbaijan, Tajikistan, and Turkey—are currently endemic for malaria.[18 23] The importation of cases into other countries, from both eastern Europe and beyond, has been increasing.[24] Climate change may increase the risk of reintroduction of malaria in eastern Europe unless programmes to control vectors are maintained or increased. In western Europe, climate change increases the risk of airport malaria, which occurs when people are infected by mosquitoes that arrive on aircraft. Six cases of malaria were described in and around the main airport in Paris during the hot summer of 1994.[25]

Visceral leishmaniasis, transmitted by sandflies, is endemic in countries bordering the Mediterranean and has become an important coinfection with HIV.[26] With climate warming there is a risk of visceral leishmaniasis extending further north in Europe.[18] Tick borne encephalitis is present in southern Scandinavia and central and eastern Europe. A study in a highly endemic region of Sweden found that the incidence of tick borne encephalitis increased with extended spring and summer seasons during two successive years.[27] Climate change may extend both the length of the transmission season and facilitate spread of tick borne diseases—including tick borne encephalitis and Lyme disease—to higher latitudes and altitudes.

Adapting to climate change

The targets for emissions of greenhouse gases agreed in Kyoto, Japan, under the United Nations convention on climate change, are likely to have little effect on the projected rises in temperature within the next 50 years.[28] As we are already committed to climate change, societies will need to adapt to minimise the adverse effects on health and society. Potential options for adaptations to reduce health impacts include strengthening public health programmes, including disease surveillance systems, and vaccination programmes for diseases such as tick borne encephalitis.[4]

Most current surveillance systems for infection have been designed to detect particular causes (for example, foodborne disease) and individual risk factors (for example, overseas travel or immune deficiency). The monitoring of climate change requires a different perspective. The epidemiological challenge is to take a more holistic approach to the causes of infection, examining the possible influence of climate both on the environmental sources of pathogens and on human behaviour. Although the seasonal variation in many infections is well established, the reasons for the rise in infections at certain times of the year are less understood (for example, the rise in *Campylobacter* spp in mid May in the United Kingdom[29]). Another challenge for studies of climate is the size of datasets required: although trends in any one country will be a

Infection surveillance criteria for investigation of effects of climate change

Surveillance criterion	Example	Gaps in present surveillance or knowledge
Strong environmental cause	*Cryptosporidium parvum:* animals and water sources	Environmental links insufficiently understood; lack of coordinated surveillance on water related disease
Low case-case transmission	*Campylobacter jejuni*	Not nationally collated in some European countries; some questions about cause
Suitable for continuous surveillance	*Salmonella* spp, food poisoning	Surveillance focused on food factors: difficult to distinguish climate effects from case-case spread, etc
Evidence for climate effect on vector breeding sites	Malaria, tick borne disease	Infrequent and complicated by association with travel
Public health measures available	*Legionella pneumophila*	Infrequent and complicated by association with travel
European reporting networks established	ENTERNET for salmonella and *Escherichia coli O157*; EWGLI for legionnaires' disease	Several other surveillance systems in place, but datasets generally limited for risk factors and exposures

Evidence suggests that organisms listed are sensitive to climatic factors, although in many cases precise mechanism and strength of relation in practice requires clarification.

starting point, improved coordination of data on infection across Europe will be needed.

The WHO-European Centre for Environment and Health working group on the early implications of climate change for human health has identified four priority infections for surveillance during climate change in Europe:

- *Campylobacter* spp
- *Cryptosporidium parvum*
- Malaria
- Tick borne encephalitis.[18]

The table lists other criteria that are important for a comprehensive pan-European surveillance initiative in addition to known or suspected linkages with climate and weather. Infections imported to Europe, such as cholera or malaria, may also prove important in monitoring the effects of climate change outside Europe and also the implications for travellers. The effect of extreme weather events such as heatwaves, weather related episodes of air pollution, and floods need to be included in the enhanced surveillance for the assessment of future impacts. There is also a need to link health surveillance activities with global monitoring systems that are being developed for the climate, oceans, and earth's surface.[30]

Conclusion

The potential difficulties in forecasting impacts on the health of the human population should not be an excuse to delay precautionary action to reduce greenhouse gas emissions in view of the inadequate progress made in international negotiations on climate change.

Few countries in Europe have undertaken national or subnational assessments on the impacts of climate change on human health.[31 32] There is an urgent need to consider how to improve research and monitoring, how to minimise adverse health impacts, and how to achieve Europe-wide coordination, sharing of information, and participation in wider international efforts in this area.

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A lesson learnt

Pride before a fall

As a newly qualified doctor and with a first job as casualty officer I saw a boy of 14 with a tender swelling in his left groin. I diagnosed an inflamed lymph node and asked him if he had a sore wound or spot on his leg or foot. He said yes, on his knee. This seemed to be a good teaching point, and, flushed with the success of my apparent clinical acumen, I sent for the two student dressers. On examining the patient, one suggested a femoral hernia; the other wondered about a lymphosarcoma. I said I thought that it was simply an infected lymph node and asked them what questions they should put. There was no immediate response so I said that they should ask the boy if he had any sore spots or cuts on his leg. Anticipating gasps of appreciation I proceeded to roll up the patient's left trouser leg. Alas, as I began this manoeuvre the boy said, "The spot's on the other leg, Doctor." This was my first clinical "shock" and proved a salutary lesson that cured me of over confidence for life.

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