World Meteorological Organization

SUPPLEMENT TO GUIDELINES ON BIOMETEOROLOGY AND AIR QUALITY FORECASTS

PWS-16 WMO/ No. 1400

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Chapter 1
INTRODUCTION

This document has been produced as a supplement to "Guidelines on Biometeorology and Air Quality Forecasts" WMO/TD No. 1184. It addresses the specific aspects of human biometeorology related to human disease, which was not included in that publication. It should be consulted in conjunction with WMO/TD No. 1184.

The guidelines are intended to provide useful advice to National Meteorological and Hydrological Services (NMHSs) on methods of incorporating air quality forecasts and biometeorological information into the suite of products and services offered to the public. The Public Weather Services (PWS) Expert Team on Product Development and Service Assessment developed the original guidelines at the request of the Commission on Basic Systems (CBS). This supplement was developed by the Public Weather Services (PWS) Expert Team on Services and Products Improvement. It is acknowledged that several NMHSs already provide this type of information while others are on the verge of developing an air quality programme. However, all NMHSs should find this document useful, especially those in developing countries that are seeking to develop or improve their national public weather services delivery while, at the same time, attempting to come to terms with some aspects of the widening array of environmental issues.

There is a growing awareness of the linkages between human health and the weather and climate that should be incorporated into the content of national public weather services programmes. An increasing number of NMHSs include specific environmental information into their public bulletins with the goal of improving public understanding of relevant environmental issues. This information enables people to take actions to minimise adverse environmental effects or stress. Timely air quality information can assist the public in coping with problems caused in urban and in some rural areas by ground-level ozone, sulphur dioxide, nitrous oxide and particulate matter. Air quality advisories, issued when predetermined pollutant thresholds are met or exceeded, should result in actions to reduce pollution levels and encourage people to avoid polluted areas helping to alleviate adverse health effects. Examples of actions that people can take in response to NMHS air quality advisories include using public transportation, staggering of work hours or even staying indoors. In addition, such advisories can help ensure that medication is readily available for people at risk from respiratory and cardiovascular diseases. Industry and regulatory agencies may decide on temporary shutdown of polluting factories, thermal power plants, banning some categories of vehicles from urban centres and closing government offices.

Several environmental conditions can be associated with the enhancement of airborne pollen. While the pollen season is reasonably well known (by many people), (but) allergy sufferers benefit most from information on the exact time of ripening and release of pollen, so they can take action to minimise the adverse effects on their health. The presence of pollen, its density and trajectory, as well as the possibility of being removed from the atmosphere by showers, all depend on the day-to-day weather.

Increased ultraviolet (UV) radiation has been shown to increase the incidence of skin cancers and eye cataracts in humans, and may also affect plants, aquatic organisms and other natural systems. The monitoring of UV values and incorporation of the measurements into a simplified UV-index can alert people to protect themselves during critical periods of elevated UV intensity by avoiding outdoor activities, wearing protective clothing and using chemical sunblocks.

The spread and extent of human diseases is influenced by the climate and weather. Some pathogens only thrive in certain conditions, and also the effect of weather on the vectors that carry the diseases is an important consideration. The expansion of a diseases' range of viability due to climate change can be serious, as previously unexposed human populations can be infected.

Chapter 1 of this document introduces the importance of, and rationale for the original guide and this supplement; Chapter 2 covers human biometeorology related to human disease and should be considered complementary to Chapter 2 of the original document.

Chapter 2
HUMAN BIOMETEOROLOGY (Diseases)

2.1 HUMAN DISEASES FROM BIOLOGICAL AGENTS

2.1.1 Overview

The second chapter of WMO/TD No. 1184 specifically focused on human biometeorology. This current chapter, in comparison, examines the issue of human disease, which was not discussed in the original document. The definition of human diseases in this document is limited to maladies related to biological agents. Those related to non-biological agents are well covered in the original document.

Weather can play a significant role in the nurturing and propagation of biological agents that can cause or carry human disease agents. Providing services to alert the public or emergency responders to the dangers can be either direct (e.g. specific forecasts or reporting of conditions that are conducive to the spread of particular diseases) or indirect by means of public education. An example of direct services may be the provision of wind trajectories to emergency service organizations after a biological spill. Indirect services may include ongoing public education about the dangers of mosquitoes breeding in standing water after rain.

Some of the forecasting tasks for disease management are similar to those related to other biometeorological events. For example, monitoring the spread of airborne anthrax spores resulting from an accident at a biological research laboratory would require similar hydrometeorological services as required after an accidental release of airborne contaminants at a nuclear research facility.

2.1.1.1 Scope of Discussion

The scope of the original document is specifically limited to the influence of weather on humans. Initially, the subject of non-human diseases (*e.g. Foot and Mouth*) were considered for this supplementary document. However, since the scope of the original document was limited to direct human effects, this complementary supplement is also restricted to the discussion of human diseases. It is important to note that there is some repetition between this supplement and WMO/TD No. 1184 particularly related to the allergenic affects of biological materials.

2.1.2 Infectious Diseases

Obvious relationships exist between seasons and some common diseases. Table 1 shows those conditions that are associated with certain seasons. Notably, in the tropics, the summer diseases reach a maximum in the rainy or humid season, while the winter diseases peak during the dry season. The fluctuations are closely related to humidity and temperature.

Summer	Autumn	Winter
Cholera Typhoid Fever Polio Bacillary dysentery	Streptococcal infections Scarlatina Diphtheria	Common cold Influenza Lobar pneumonia Epidemic meningitis

Table 1: Most Common Seasonal Diseases (*source Tromp, 1980*)

Hydrometeorological conditions can influence infectious diseases in two major ways; altering the resistance of the human body to infection or affecting the spread of infection. Many of these relationships are well known in society; however, it is useful to be reminded of these influences. Also, as hydrometeorological conditions conducive to the spread of certain diseases are predicted, advice on preventative measures can be broadcast and medical facilities prepared for influxes. The most common measure is the annual flu-shot programmes that are performed by many countries prior to the winter season.

2.1.2.1 Ease of Spread of Infection

Weather conditions will influence the activities and habits of people as they proceed with their day-to-day life. This can affect the ability for communicable diseases to pass from person to person. Inclement weather can encourage the crowding of people into poorly ventilated areas. The need to wear more clothes increases the chance of infestation by lice, etc that may be vectors of disease. Air conditioning during warm spells can circulate pathogens like Legionella in buildings. Fair weather may encourage outdoor activities like swimming, camping, gardening, etc that expose people to diseases that are endemic in nature, but are not often encountered by people in urban life. During drought conditions, or in some circumstances at the end of the dry season, people are often forced to use water and food sources of marginal quality; leading to greater chance of infection.

The growth of micro-organisms and viruses is affected by hydrometeorological conditions, particularly UV radiation, temperature and humidity. In favourable environmental conditions, disease organisms can last longer, increasing the chance of human contact. Also, conducive environmental conditions can increase growth rates of micro-organisms and viruses in contaminated foods potentially increasing infection rates. For example, warm conditions and below normal rainfall can lead to stagnant watercourses, which may lead to dangerous algal blooms. The (UK) Met Office has used its Numerical Atmospheric dispersion modelling Environment (NAME) to model the spread of Foot and Mouth Disease and Blue Tongue disease. The approach could be used to study the spread of airborne pathogens affecting humans

Hydrometeorological factors can also affect the physical spread of infectious agents. Airborne pathogens can be spread by wind while waterborne pathogens are dispersed by stream flow – particularly by flooding where measures taken to protect water supplies from contamination are often compromised. Weather supporting vectors of disease, supports the spread of disease.

2.1.2.2 Human Resistance to Infection

The human body is affected by its environment and, in turn, can affect its ability to defend itself from attack. For example:

- Thermal stresses can affect the permeability and capillary resistance of membranes – the level of permeability being positively correlated to temperature.
- The coating of the skin may be affected by temperature and atmospheric pH. This can affect the ability of pathogens to survive on the skin surface, or penetrate into the skin.
- The dryness of mucous membranes affects their protective ability.
- Evidence suggests that ozone in high concentrations can lower resistance to respiratory infection – at least in test on mice.
- Hot or cold spells can affect the internal chemistry of the human body and this may affect the viability of infections. Where the body's ability to maintain normal temperature is compromised, the common clod often takes advantage. Stress due to cold can cause 17-ketosteroid levels to rise, reducing resistance to infections.
- Varied diet between seasons can also affect body chemistry.

2.1.3 **Botanical and Viral Agents**

2.1.3.1 Bacteria and Viruses

Unusual weather can lead to conditions conducive to the growth of populations of bacteria or viruses. Human contact with these colonies can lead to disease. The most common examples are poisoning due to the consumption of contaminated food or water. Bacteria will grow rapidly in food left in warm and/or humid conditions – this may be on a market stall, or in poor storage conditions resulting from inadequate or compromised measures to avoid contamination. Bacteria on surfaces or utensils may thrive in the correct conditions.

Also, some bacteria in natural environments may only be a threat under certain conditions. For example, Meliodosis (known as Nightcliff Gardener's Disease in Northern Australia) can strike people who are working with soil. A soil bacterium (*Burkholderia pseudomallei*) is exposed in heavy rain and can enter the body via small cuts or inhaling dust.

2.1.3.2 Fungal Agents

There are few fungal agents that cause problems in humans, and these mostly relate to skin irritations. The main link with weather is the fact that they usually thrive in warm moist conditions. The exceptions are fungal spores such as *Didymella exitialis, Alternaria alternata* and *Cladosporium cladosporioides* that are widely distributed and grow on cereals and grasses. Fungal spores as aeroallergens increase to very high levels in late summer.

2.1.3.3 Allergenic Pollen Grains

With respect to allergenic pollen, Germany is an example of how pollen is treated in relation to health problems. More than 10 percent of the German population suffers from pollinosis – also known as Hay fever; a catarrhal affection of the mucous of the eyes and respiratory tract – and this tendency is on the increase. The main allergenic pollen grains are from hazelnut, birch, alder, grasses, rye, and mugwort. The regionalised daily pollen forecast in Germany is based on the weather forecast from their NMHS, Deutscher Wetterdienst, (DWD); on measured pollen data from about 50 stations in the Foundation Pollen Information Service network; and on up-to-date phenological data. Subsequently, the pollen forecast text is automatically generated. Forecasts are available on the home page of the DWD.

2.1.3.4 Thunderstorm Asthma

People with pollen and fungal spore allergies are also vulnerable to thunderstorm asthma. Thunderstorm asthma events occur infrequently but can overwhelm healthcare providers. The last major event in the UK occurred on 24 June 2005 and led to attendances at "Accident and Emergency" 8-times the expected levels. The mechanism is complex and requires a susceptible population; favourable meteorological conditions for pollen/spore production and viability; and mesoscale thunderstorms with outflows. As part of its Health Forecasting programme, the Met Office has been working with pollen forecasters to predict thunderstorm asthma events, and with hospitals and general practice to help them plan and respond.

2.1.3.5 Algal Blooms

About 300 species of micro algae are reported at times to form blooms, of which up to 80% can produce toxins – some of which are dangerous to human health. Phytoplankton blooms, micro-algal blooms, toxic algae, red tides, or harmful algae, are all terms for these naturally occurring phenomena. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) runs the IOC Harmful Algal Bloom (HAB) Programme, which studies these phenomena and the threat to human health. Not all HABs are 'algal' and not all occur as 'blooms'. Details on the nature of these phenomena and the impacts they cause are available at (http://ioc.unesco.org/hab/default.htm).

HAB related human diseases can be caused by consumption of contaminated seafood, or direct ingestion. Contaminated seafood consumption can lead to the following five recognized human illnesses: amnesic shellfish poisoning; ciguatera fish poisoning; diarrheic shellfish poisoning; neurotoxic shellfish poisoning; and Paralytic shellfish poisoning. Blue-green algal toxins in drinking water can cause direct injury and can be carcinogenic. People may also be exposed to and inhale aerosolized HAB toxins near the beach.

Oceanic algal blooms will generally be predicted and tracked by oceanographic organizations. However, they can liaise with NMHSs, or use their services, to help in the prediction of conditions conducive to blooms along with the surface winds when considering the spread of existing blooms. Seasonal forecasts can determine the likelihood of water temperatures necessary to support algal blooms and the flushing of nutrients from nearby rivers.

Blue-green algae blooms in inland waterways are more weather dependent. They can be promoted by: nutrient levels; stagnating water; long-term warm and stable weather patterns. Blue-green algal blooms often persist for several weeks, sometimes months, depending mainly on the weather or flow conditions. Toxins are released as the algae die, these can persist months.
(http://www.nrw.qld.gov.au/water/blue_green/blue_green.html)

2.1.4 **Animal Vectors**

The most deadly vector borne disease, malaria, kills over 1.2 million people annually, mostly African children under the age of five. Dengue fever, together with associated dengue haemorrhagic fever (DHF), is the world's fastest growing vector borne disease.

Known contributing factors to the most common vector borne diseases (i.e. malaria, dengue and leishmaniasis) include poorly designed irrigation and water systems, inadequate housing, poor waste disposal and water storage, and deforestation and loss of biodiversity. As shown in Figure 1, there is an obvious maximum in vector borne diseases in tropical regions. This may be partially attributable to human habitat management.

Diseases that cannot survive in the open environment often rely on animal vectors. Thus, while the disease itself is not subject to the elements, it still relies on the viability of the animal in the weather-affected environment. The most common animal vectors for disease are insects, although some small mammals (e.g. rats) do offer a method of transport for the disease bearing insects (fleas). Predicting the threat and spatial extent of a vector-borne disease will rely on predicting the presence of appropriate vectors in numbers necessary to sustain the disease.

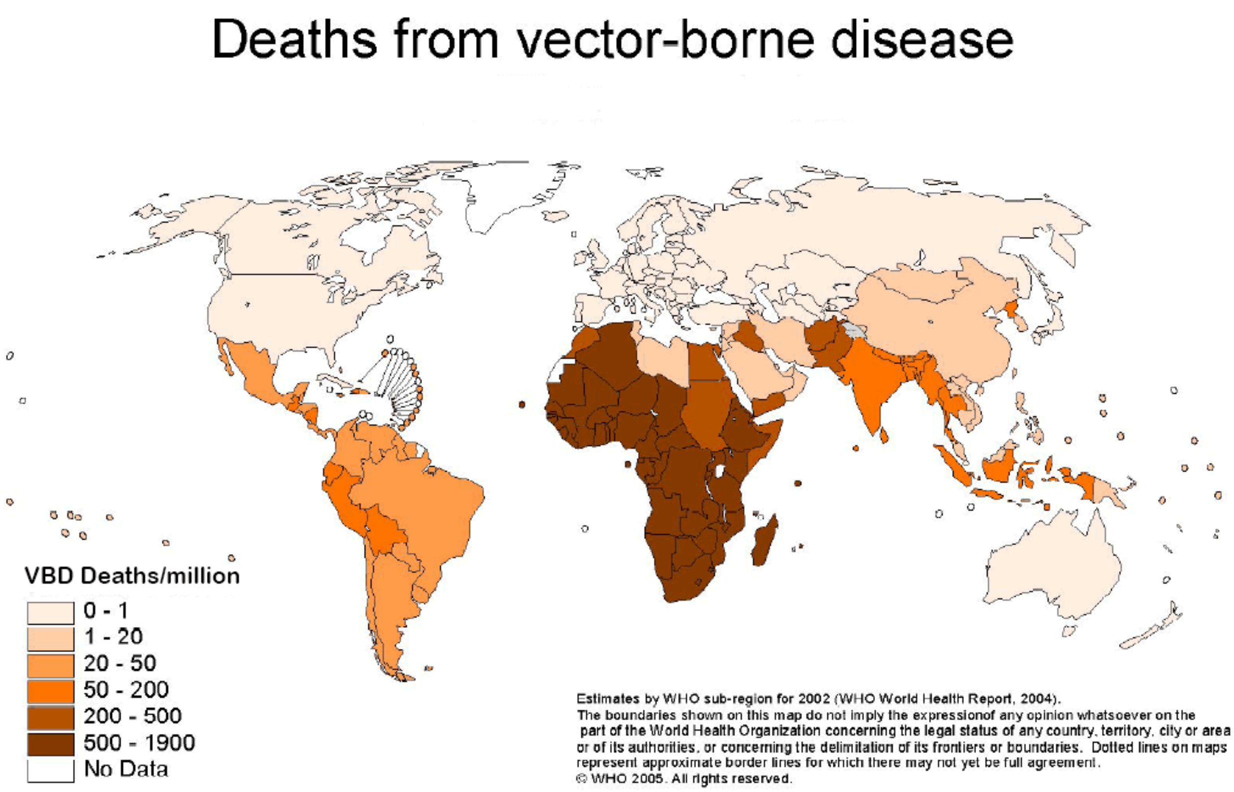


Figure 1: deaths from vector-borne diseases: http://www.who.int/heli/risks/vectors/vector/en/index.html

Rodents, birds and similar animals

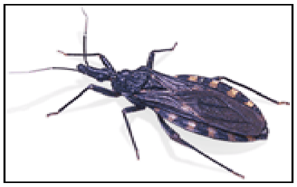
Many small, disease-carrying mammals can exist in most urban environments and survive – at least for limited periods – in quite harsh conditions. Usually, routine methods of control will keep diseases carried by these animals under control. Extra care is required when unusual weather conditions may change the habits of the animals, bringing them in closer contact with humans or the human environment.

Bird diseases do not usually affect humans, however on occasion strains can cause flu-like outbreaks, and in the worst-case scenario mutate to develop into major flu pandemics. The latest threat is posed by Severe Acute Respiratory Syndrome (SARS) and the H5N1 strain of Avian Flu, particularly in Southeast Asia. Research at the Hong Kong Observatory, suggests some correlation with weather conditions (Chang, et al, 2005)

Water-related insects and crustaceans

Mosquitoes, tsetse flies and black flies are insects that breed in water and transmit diseases such as malaria, filariasis, dengue fever, yellow fever, onchocerciasis, and African trypanosomiasis. These most often prefer tropical or sub-tropical environments, relying usually on still water sources. In warm climates, flooding, localized downpours, or simply the onset of the wet season can lead to increased incidence of these diseases as the insect populations explode. Other water-borne vectors include the water snail (causing schistosomiasis) and copepod (a crustacean causing dracunculiasis).

Other specific disease carrying insects



Other insects that carry disease include the Triatomine bug (causing American trypanosomiasis), phlebotomime sandfly (causing leishmaniasis) and Vinchuca Bug (*illustrated* - causing Chagas' disease). The Vinchuca is endemic throughout Central and much of South America and is a serious public health problem. It is a tropical insect, however can survive in the relatively warm environments of homes and farm buildings in temperate zones; transported there by human activities.

Flies, cockroaches

These types of insects simply contaminate objects and food used by humans with bacteria by transporting the pathogens on their body parts. Generally warmer weather will foster the growth and spread of these insects as they are able to breed more easily, and also travel in the open between hospitable environments (like sewers and houses). This will increase the amount of contact with humans and also the likelihood of spread of pathogens between environments.

2.2 EVENTS AFFECTING HUMAN DISEASES

2.2.1 Natural Disasters

Natural disasters can wreak havoc on human infrastructure and biological ecosystems. Weather –particularly heat and excess rainfall – either associated with, or following, a natural disaster can significantly affect the spread and fostering of human diseases. The most common problem is with water. This can be in the form of human water supply infrastructure being compromised, or overwhelmed in the case of flooding. These conditions will promote water-borne diseases such as cholera, or water-borne vectors, such as mosquitoes spreading malaria. Rainfall after such events can also lead to a supply of stagnant water sources that would have normally not existed if no disaster had occurred.

Last Update: Tuesday, March 6, 2007. 2:00pm (AEDT)

Mosquito-borne disease warnings issued for flooded Top End

Disease and electrical problems are the biggest concerns for Northern Territory authorities as they start a massive clean-up operation in the flooded community of Oenpelli, on the eastern border of Kakadu National Park.

Heavy rainfall has prompted the NT Health Department to issue warnings for Kunjin Virus and the potentially fatal Murray Valley Encephalitis for the Top End over the next five months.

The common banded mosquito, which carries the disease, breeds in flooded grassy and swamp areas and the department, expects high insect numbers will persist over the dry season.

Around 90 people are still in shelters and many more are staying with friends while workers try to sanitise the 67 inundated houses and electrical contractors assess damage to wiring.

Environment Health director Xavier Schobben says the flood waters are receding but there is still a long way to go.

"I'd like to think that some houses can be done today but I think that's going to be an ongoing issue probably for the next three to four days, depending on the flood water - if it subsides," Mr Schobben said.

The Gunbalunya School will be closed all week as the recovery effort continues.

News report from ABC News Online: www.abc.net.au/news/

Example of a health warning issued in Australia's Northern Territory following floods.

The impact of the disaster on populations also needs to be considered. As people are displaced, or deprived of food or water, they can become weakened and thus more susceptible to opportunistic diseases. It is at this time that extra consideration needs to be given to the effects of rainfall and temperature on the compromised environment. Forecast deteriorations of weather conditions may help recovery teams make appropriate actions to mitigate these possible disease sources.

Bio-terrorism

An act of bio-terrorism is always a possibility in the current world political environment. The incidents that are most likely to cause significant effect would be the release of an airborne pathogen, or contamination of a water source. The application of hydrological modeling and real-time air-dispersion modeling would be required to mitigate the affects of such incidents and target the needs of emergency service actions.

The treatments required for these types of events are similar to those for chemical spills or atmospheric releases of noxious or radioactive gases. A recent oil fire disaster in the UK at Buncefield on 11 December 2005 illustrates the role that the Met Office plays in these situations, providing forecasts and data based on atmospheric modelling, aircraft observations and close liaison with emergency services and the Civil Contingencies Secretariat (see Jones, et al, 2006).

2.3 IMPACTS OF GLOBAL CLIMATE CHANGE

A detailed discussion on the impact on human health of climate change is detailed on the World Health Organization website, which can be found at: http://www.who.int/globalchange/climate/summary/en/. As discussed above, many diseases rely on certain environmental conditions, or ecosystems that are related to climate. As the world's climate is affected by anthropogenic factors, the climatic conditions will vary in various parts of the world. These changes will allow for the spread of certain diseases into new regions and exposing new populations to the threat of these diseases. Such populations are likely to be more susceptible to these diseases, and less prepared to manage the diseases and their underlying causes. (see Figure 2)

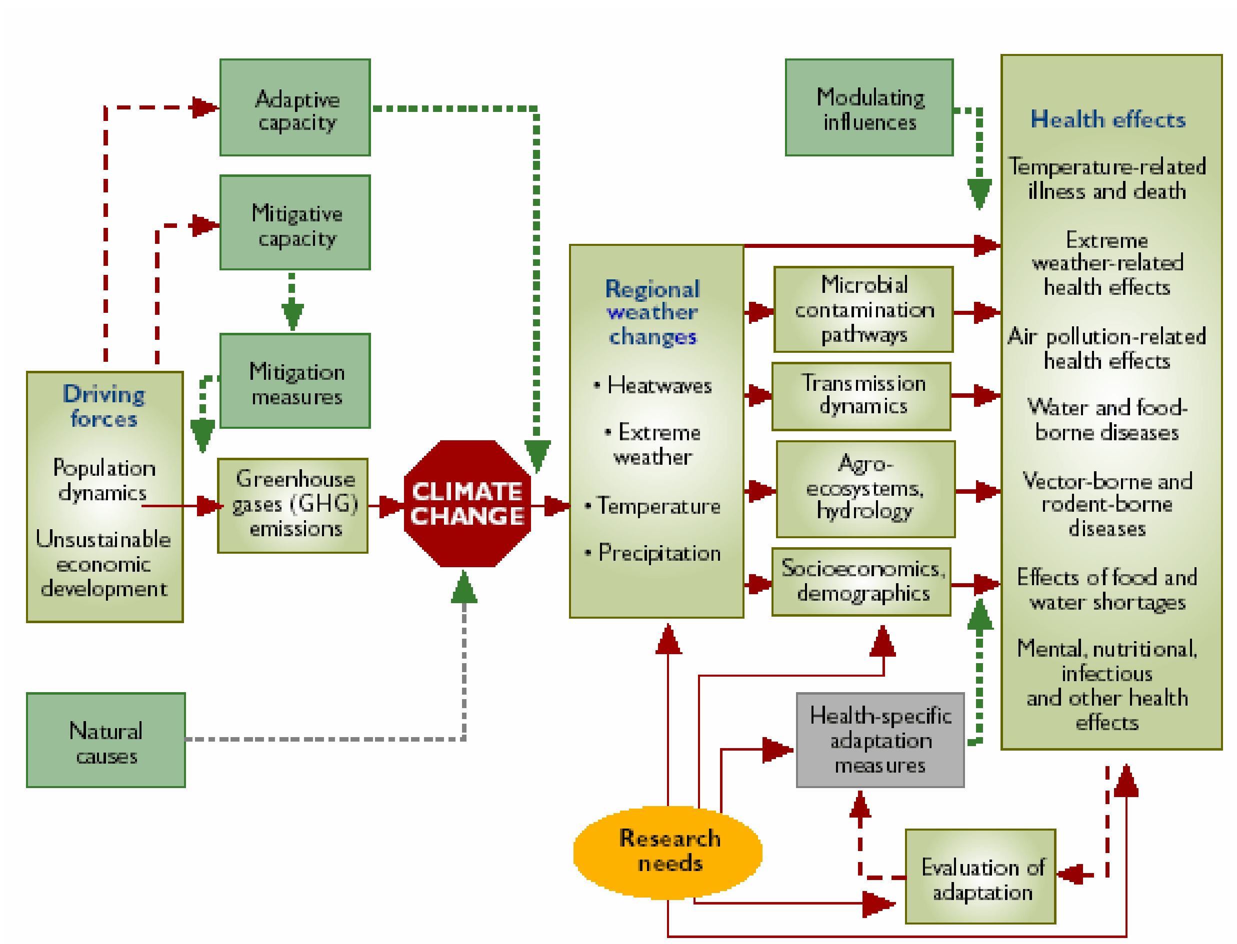


Figure 2: Climate change and health: pathway from driving forces, through exposures to potential health impacts. Arrows under research needs represent input required by the health sector.
Source: http://www.who.int/globalchange/climate/summary/en/index4.html

While climate change is already occurring, the change is relatively slow. Although some scenarios may suggest some localized rapid change, most communities will have the opportunity to predict the ingress of new diseases into their environment in a timely manner and take actions to limit their impact. To accomplish this, communities must understand the nature and viability of these diseases in certain environments, and the likely changes that are going to occur in their surrounding environment. When considering diseases that are not currently viable in their region, they also need to consider the possibility of diseases that exist elsewhere in the world. Often these diseases have been isolated from the local ecosystem by an intervening hostile environment that may now become more hospitable as a result of climate change. It has been observed that the Vinchuca Bug is spreading southwards through Chile and Argentina, as the climate is getting warmer.

In addition to the increase in disease-friendly environments, climate change will likely result in more extreme hydrometeorological events which may overwhelm existing communities' infrastructure (e.g. water treatment plants, sewers, etc).

The Met Office Hadley Centre analysis has indicated that the likelihood of extreme events like the 2003 European heat wave will increase, and that it will be a 'normal' summer by the 2040s.

2.4 RESPONSIBILITIES OF NMHSs

2.4.1 Collaborative Arrangements

While the management of human diseases is outside the scope of hydrometeorological services, organizations involved in disease management and impact mitigation will likely rely on routine hydrometeorological information provided by NMHSs. Seasonal hydrometeorological variations will also be quite routine and the health authorities should be aware of these effects and possible impacts.

It will generally be the responsibility of government health departments or hospitals to manage disease outbreaks and the study of diseases, their causes and any correlations with external factors. There is also a role for medical research establishments within the higher education sector. The Met Office has worked with John Moore's University in Liverpool to create a useful document on weather forecasting as a public health tool (S. Hughes et al).

The hospital sector will have a dual purpose when considering disease studies; the mitigation of disease and the logistical and contingency planning for operations.

These organizations will need to utilize the expertise of meteorologists and hydrologists when weather-related health issues need to be considered. This is where the NMHS will play a significant collaborative role in research, and also the provision of data for real-time events, and historical epidemiological studies.

An example of collaborative research can be found in the UK where The Met Office has worked with the National Health Service in England to develop a Health Forecasting and Anticipatory Care service for patients with Chronic Obstructive Pulmonary Disease (COPD). The Met Office has developed a forecast model of weekly risk of exacerbation of COPD, driven by season, weather and prevailing infectious diseases. Forecasts are provided to general practices, which maintain a register of COPD patients and the severity of their disease. Depending on the forecast, practices contact their patients to ensure that they are taking simple actions to reduce risk. The Met Office has developed a patient education pack with input from an Advisory Group of clinical experts. The recommended actions for patients include: ensuring that they keep warm indoors and out, that they have sufficient medication in case their symptoms worsen, that they take enough exercise. The service has seen benefits in terms of improving COPD care across the patient pathway, reduced admissions for COPD, and improved quality of life.

2.4.2 Specific NMHS Roles

The role of the NMHS will likely become more prominent under the following circumstances:

Unusual or extreme weather events
- During disaster situations
- Outbreaks (natural or man-made)
- Climate change
- Year-round weather and air quality
- Forecasting impacts and working with others to reduce risk

Unusual or extreme weather conditions can lead to conditions that are amenable to diseases that are uncommon to a region. This kind of situation can lead to disease outbreaks that are beyond the scope of typical mitigation processes that currently exist within a community. The community needs to be informed of the unusual nature of the weather conditions and potential impacts.

Disasters can also overwhelm normal mitigation processes and produce environments conducive for disease. In these situations, other hazards to human health will also exist, and the NMHS would already be closely involved in the recovery process.

Disease related outbreaks could be attributed to an event of known or unknown origin. In the case of an outbreak of a known disease (e.g. the release of an airborne pathogen), there are usually systems in place that deal with similar threats (e.g. release of an airborne poison) that can be applied. For diseases of unknown origin, recent environmental conditions need to be examined to determine possible sources of the disease. This may include locating where conditions amenable to insect vectors may have occurred/are occurring. For example, in the case of isolated outbreaks of Legionnaires Disease, tying weather records with the activities of the known victim(s) may assist the location of the source.

Climate change will cause the spread of exotic diseases as conditions amenable to these diseases extend over new areas and new populations. It can also cause the spread of invasive plants, which may create new health risks, for example the spread of Ambrosia in Europe with its high allergenic potential. The prediction of potential changes in climate that could promote the spread of new diseases and allergies can be used to assist unprepared and unprotected communities in developing effective mitigation plans. NMHSs and climatologists will need to work with local communities and health authorities to assess potential risks and determine what actions needs to be taken to help communities protect their citizens from new disease threats.

2.4.3 **Quantifying Disease Risk**

Recent initiatives between health authorities and NHMSs have led to the introduction of indices for PWS; like UV, wind chill, comfort index etc. There is scope for extending this concept to develop biomet indices and the potential application of such indices for PWS in health hazard warnings. We probably need a more strategic approach, at global, regional as well as NMHS levels, to develop more such indices to reflect the full scale of the problems highlighted. Issues that need to be addressed in the future:

(a) can some of the newer problems be meaningfully defined for useful algorithms to be devised?

(b) standardisation or inventory of standard algorithms in use?

(c) calibration of indices and classification for potential health impact according to climate regimes or geographical regions?

data bank of such indices for long term study of climatic impact?

Chapter 3
OUTLOOK

There is no denying that NMHSs have an important role to play in environmental issues, extending to the consideration of human diseases. With their already well-established global network of weather observing stations and a well-connected global telecommunication network (GTS), NMHSs only need to enhance their observation programmes to include environmental monitoring. Many of the air quality models also include weather forecast models as one of the components and/or require weather input. It is also important for NMHSs to be engaged in issues related to human health with an emphasis on unusual events/situations, particularly post-disaster (natural or otherwise). The introduction of quantitative indices will help in the communication of risk.

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