

# The Health Benefits of Mitigating Global Warming in Australia



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## Executive Summary

**T**his report reviews the literature about public health impacts of climate change due to global warming as predicted for Australia in the coming decades. As well as a general increase in temperature of as much as 6 degrees C by 2100, there will be reduced rainfall, increased extreme weather events - droughts, storms, floods and tropical cyclones - and raised sea-levels.

None of these changes is in doubt, and all of them impact on human health. Apart from contributing to illness and death in Australia through localised air pollution, the burning of fossil fuels is bringing a whole new range of risks to the health of the Australian public by creating climate change. Adding carbon dioxide to the air as we do creates an unhealthy atmosphere for ourselves and our children.

All manner of disease – infectious, mosquito, food and water-borne – will be affected by the changes in climate predicted for the coming century. In most cases these changes will increase mortality and morbidity from disease in Australia. For example, it is probable that there will be an increase in bacterial food borne disease in Australia, such as Salmonella infections, particularly in temperate climates.

The cost of these public health impacts is huge. Ross River virus infection in Australia already costs between A\$2.8 and A\$5.7 million per annum. This disease could increase as the seasonal variation reduces and prevalence spreads. Tasmania – which reported Ross River virus infection for the first time in 1994 - experienced the largest outbreak of the disease ever recorded in the beginning of 2002.

There will probably be an increase in waterborne outbreaks of disease following unusually heavy rainfall. There is also significant likelihood that Ciguatera food poisoning, from large reef fish and mackerel, will become more widespread due to warming waters and increased El Nino conditions. For the same reasons, algal blooms may increase along the coast of Australia with a number of negative effects.

The increase in flooding, cyclones, drought and bushfires will have an obvious impact on the health of Australians. It is also possible that as the weather becomes hotter and drier, we will become more susceptible to air pollution. For example, increased dust conditions as predicted by hotter and drier conditions clearly contribute to asthma sensitivity and it is speculated that the growth of some plants and fungi in greenhouse conditions will increase hay fever and related illness.

The only silver lining in this dark cloud is that there may be a decrease in winter-related deaths in Australia. The mortality rate is higher in winter than in summer months due to respiratory disease including influenza. The trade-off is unclear, however. It is difficult to predict whether increases in temperature will result in more people dying from heat-related stress, than will not die due to more mild winters.

Regardless, it is clear that people who are already vulnerable – especially Indigenous Australians, the impoverished and the elderly – will be most vulnerable to the health impacts of global warming. Climate change could significantly increase the already growing gap in health between the rich and poor. Measures taken now to reduce carbon emissions can avert some of these negative outcomes and will have significant additional positive health impacts.

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## Introduction

Humans, largely through the burning of fossil fuels, have been changing the composition of our atmosphere, particularly with respect to the level of carbon dioxide. This increase in carbon dioxide and other gaseous emissions, in turn, is modifying the way in which radiant energy is absorbed or scattered, resulting in global climate change. The Intergovernmental Panel on Climate Change (IPCC), which was established by the World Meteorological Organization and the United Nations Environment Programme in 1988, has concluded that the observed warming over the past 50 years is likely to have been due to the increase in greenhouse gas concentrations, and that there are likely to be future changes in climate that will include additional warming, changes in rainfall, sea-level rise and changes in the frequency and intensity of some extreme events (1).

The impact of global warming will not be uniform around the world, and the IPCC has developed predictions of climate based on intricate modelling for each country (1). These models are constantly being revised as new data becomes available. For Australia, a tendency towards El Niño-like conditions has been predicted (2). Apart from a general increase in temperature, this will mean significant decreases in rainfall for much of mainland Australia (low to medium confidence), increases in the intensity of tropical cyclones, mid-latitude storms and heavy rain events (medium confidence), and changes in the location-specific frequency of tropical cyclones (low to medium confidence) (2). As a result, water resources will decrease, due to diminished rainfall and increased evaporation, having a negative impact on agriculture as well as biodiversity.

Many different factors impact on the health of human populations. Climate is one of these factors. The impact of climate on health can be direct, for example through heat-related illness, or indirect, through the impact of climate on disease vectors, pathogens and on human behaviour.

A considerable amount has been written on the impact of global warming on human health in other countries (3), but the literature on the impacts on human health in Australia is somewhat more limited (2). This paper reviews the studies that are available to examine the impact that a changing climate may have on our health in Australia.

Because of a decreased ability to adapt to major changes in the environment, populations who are already vulnerable, particularly Indigenous Australians, the impoverished and the elderly, will be most vulnerable to the health impacts of global warming. Thus climate change could significantly increase the already increasing gap in health between the rich and the poor in Australia (4).

## 1. Infectious Diseases

The epidemiology of some infectious diseases is clearly linked to climate, but the nature of the link is not always straightforward. The reasons behind the link between the epidemiology of some infectious diseases and climate also vary. For example, in temperate countries, influenza occurs predominantly in the winter months, while in tropical countries, influenza can occur year-round, sometimes with two peaks in incidence per year. These differences are thought to be related to the impact of climate on human behaviour. The distribution and incidence of vector-borne infectious diseases is heavily dependant on the distribution and density of the disease-vectors, which can be influenced by climate. The ambient temperature, humidity and rainfall can influence the ability of pathogens to grow and/or survive in the environment, including food, thereby influencing people's exposure to these organisms. In this section we will be discussing some infectious diseases that occur in Australia, and the possible influence of climate change on the incidence of these diseases.

### *Mosquito borne diseases*

Mosquito-borne diseases are caused by pathogens that are transmitted from human to human or animal to human via mosquitoes. The most common mosquito borne disease in Australia is epidemic polyarthritis, which is caused by infection with either Ross River virus or Barmah Forest virus. The disease is characterised by fever and arthritis or arthralgia in a number of joints with or without a rash. Some individuals experience significant fatigue on resolution of the acute phase of the illness. The arthritis can be quite debilitating, but is usually self-limiting, with most cases resolving after two weeks and almost all within six months (5).

Ross River and Barmah Forest viruses infect both humans and animals, with the natural hosts being a wide variety of Australian mammals. The incidence of the disease is highest in the coastal regions of Northern Australia, for example in Darwin and Cairns, with the incidence decreasing in more temperate regions (6). The disease occurs year-round in Northern Australia, whereas in more temperate regions, the disease occurs almost exclusively in the summer months, with large fluctuations in incidence from year to year, largely depending on rainfall (7). While there are many mosquitoes capable of transmitting Ross River virus, the three most common vectors are *Culex annulirostris*, *Aedes camptorhynchus* and *Aedes vigilax*, the former being a fresh-water breeder and the latter two breeding in salt marshes (5;7;8). Major outbreaks of Ross River virus infection have been recorded in almost all states and territories. Since 1991, more than one half of all reports of Ross River virus infection have originated in Queensland. In Australia in 1999, there were 4,416 reported cases of Ross River fever and 639 cases of Barmah Forest virus infection (6). However, this is likely to be an underestimate, as cases with the disease that are not tested will not be reported. While epidemic polyarthritis is not life threatening, it can cause significant short-term disability, and conservative estimates place the current annual cost of Ross River virus infection in Australia to be between A\$2.8 to A\$5.7 million (5).

Other mosquito borne diseases in Australia are Dengue fever, Australian encephalitis and Japanese encephalitis. These are also viral diseases. Dengue fever is an infection that causes widespread morbidity and mortality in many tropical areas of the world (9). It occurs seasonally in far North Queensland, following introduction of the virus during the wet season by international travellers, which has led to limited although sometimes prolonged epidemics (10;11). Dengue fever is a self-limiting febrile illness, but can be complicated by Dengue Haemorrhagic Fever, a life-threatening disease. Australian encephalitis is an uncommon encephalitic disease caused by the flaviviruses Murray Valley encephalitis virus and Kunjin virus. It is endemic throughout Northern Australia, and due to low population density in endemic areas, it causes very few cases every year. Japanese encephalitis is common in some Asian countries, but only occurs in Far Northern Australia. Both diseases are severe, causing death in about one third of those affected.

Malaria is a very common cause of disease worldwide and transmission has occurred widely in Australia in the past (12). The disease was eradicated in Australia by 1981.

### ***How climate change may affect the incidence of these diseases***

With increasing winter temperatures it is possible that the seasonal fluctuations in incidence of epidemic polyarthritis may reduce, with increased numbers of cases occurring in the winter months, even in temperate regions (7;13). The disease may also

become more common in summer in more temperate regions. For example, Tasmania, which recorded more than one case of Ross River virus infection in one year for the first time in 1994, experienced in the beginning of 2002, the largest outbreak of Ross River fever ever reported.<sup>1</sup> The increasing salt incursion of coastal areas subsequent to a rise in sea level may lead to increased density of *Aedes vigilax*, with consequent increase in the incidence of epidemic polyarthritis in these areas. This would particularly affect people living in coastal areas, who already have the highest incidence of Ross River virus infection in Queensland (7).

It is unlikely that climate change will result in a change in the geographical distribution of Dengue fever, as the density of the vector is largely dependent on the occurrence of domestic container breeding sites, and can therefore be modified by mitigation efforts (8;10;11). However, increased temperatures may increase the vigour of the vector where it does occur, possibly increasing the impact of an epidemic.

The most recent outbreak of Australian encephalitis in temperate areas occurred in the Murray valley region in 1974 following marked flooding in the area. It would appear that the major contributing factor to this outbreak was flooding (8). Therefore there is the possibility that increased flooding as a result of global warming may increase the likelihood of a future outbreak of the disease. However, the complex interplay of factors contributing to the epidemiology of the viruses (i.e. vector ecology, ecology of the natural host, human behaviour, human proximity), make it very difficult to make predictions on the incidence of this uncommon disease.

In spite of there being vectors capable of transmitting malaria in Northern Australia, and the introduction of the parasite by international travellers, the disease has not re-established itself (8;12). This is due to a number of factors (12). Therefore, even if global warming results in increased vector density and increased geographical spread of the vector, it is unlikely that global warming will result in a resumption of local transmission of the infection. However, it is clear that we should maintain vigilance, particularly given that many have predicted a global increase in the incidence of disease as a result of climate change (3).

***Conclusion: Probable increase in Ross River and Barmah Forest virus transmission, particularly in temperate areas. Uncertain as to whether or not a substantial increase in other vector-borne disease will occur.***

### ***Food borne diseases***

#### *The nature of food borne diseases*

Food borne disease can be caused by a number of different viruses, bacteria and parasites. Food borne disease usually takes the form of gastro-intestinal symptoms such as diarrhoea and vomiting, although occasionally more severe disease, such as haemolytic uraemic syndrome or hepatitis can result.

<sup>1</sup> NNDSS data – <http://www.health.gov.au/pubhlth/cdi/nndss/year002.htm>

The incidence of an important cause of food borne disease, *Salmonella*, increases in Australia in Northern areas, with the highest incidence of any state or territory being in the Northern Territory (6). A total of 7,154 cases of *Salmonella* infection were reported in 1999 Australia-wide, of which 356 occurred in the Northern Territory (notification rate of 184/100,000) and 2,231 in Queensland (notification rate of 68/100,000) (6). This is likely to be a great underestimate, as the majority of cases of *Salmonella* infection are not reported. A national survey of diarrhoeal disease in 2002, found that the reported experience of gastroenteritis was highest in the Northern Territory, and that there was a seasonal fluctuation of reports, with the highest report rate in the summer months (*Gillian Hall, pers. comm.*). Additionally, the incidence of reported *Salmonella* infections as well as other food borne diseases increases in the summer months (6). This could be related to a number of factors, but ambient temperature is clearly a risk factor for bacterial food borne infections, where the bacteria will multiply in food according to the ambient temperature.

#### *How global warming may affect the incidence of food borne disease*

The CSIRO has predicted that the average temperatures in Australia will rise by up to 2°C by 2030 in the absence of mitigation strategies (14). In this scenario, the incidence of *Salmonella* infection and other bacterial food borne diseases could be expected to increase. There are a number of ways to mitigate this increase, through improved food handling in food establishments and in the home, and through decreasing the pathogen load in food animals. However, as these strategies are already in place, we can expect that they will continue to be fallible.

**Conclusion: Probable increase in bacterial food borne disease in Australia particularly in temperate climates.**

## **Waterborne disease**

### *Nature of the diseases*

Diseases can be transmitted through either drinking water or recreational water. Generally the infectious diseases transmitted through water result from faecal contamination, either from animals or humans, coupled with inadequate treatment. As, except in outbreak settings, it is not possible to determine the contribution of waterborne disease to the overall incidence of diarrhoeal disease in the community, the current disease burden in Australia due to waterborne disease is not known. As a single water supply can provide water to a large number of people, it is possible to have very large outbreaks of waterborne disease. The largest recorded outbreak in any developed nation occurred in Milwaukee, USA in 1993, where an outbreak of cryptosporidiosis in the community affected an estimated 403,000 people with 54 deaths (15).

Cryptosporidium is a parasite that can cause watery diarrhoea, and severe disease in immunosuppressed individuals. As it is resistant to normal levels of chlorine in drinking water, high par-

asite levels can overwhelm filtration and get into the drinking water in sufficient quantities to cause outbreaks of disease.

Algal blooms and biological toxins have become an increasing problem in our oceans. They can have a direct impact on human health by direct contamination through swimming or exposure to sea spray, or they can contaminate seafood and cause disease through the food borne route (16). The most common food borne toxic disease in Australia is Ciguatera food poisoning (16). This toxin, found in some fish, causes neurological symptoms that can be long lasting.

### *How climate change may affect the incidence of these diseases*

The Milwaukee cryptosporidiosis outbreak described earlier occurred after a period of heavy rainfall (17). An analysis of 548 reported waterborne outbreaks in the USA from 1948 to 1994, showed significant association between the occurrence of waterborne outbreaks and heavy rainfall (17). This included outbreaks related to both contaminated surface water as well as groundwater.

Heavy rainfall causes pollutants to enter the water system, both in rivers and by overwhelming the natural filtration processes for groundwater. With global warming it has been predicted that most of Australia will become drier, but the rainfall that does occur will occur in heavy falls. This could predispose to waterborne outbreaks, especially in situations of inadequate water treatment.

Heavy rainfall can also result in contamination of the sea with pollutants, including infectious agents. This can also result in disease if people swim in the sea during the times that it is polluted (16).

There is evidence that, subsequent to the El Nino phenomenon, increased sea surface temperatures resulted in increased ciguatera food poisoning in some Pacific islands (18). While we do not have an adequate surveillance system to detect cases, we know that ciguatera food poisoning is not uncommon in Australia among people who eat large reef fish and mackerel, and it is plausible that this may increase with increasing sea temperatures. It is also plausible that, while the toxin is currently limited to fish caught in tropical and sub-tropical waters, it may become more widespread with increasing sea temperatures.

While the causes of algal blooms are multifactorial, there is evidence that they increase with increasing seawater temperature (3). Therefore algal blooms would be expected to increase with global warming.

**Conclusion: Probable increase in waterborne outbreaks of disease following unusually heavy rainfall, probable increase in ciguatera food poisoning.**

## **Other infectious diseases**

There are a number of infectious diseases whose causative agents occur in the environment and therefore that can be affect-

ed by climate (9). Examples include leptospirosis and melioidosis, which are more likely to infect people in warm, moist conditions, and anthrax and Q fever, which are more likely to infect people in dusty, windy conditions. It is not possible to predict the effect of climate change on the overall health impact of such diseases, as the increased morbidity and mortality caused by the increase in one may be offset by the decrease in morbidity and mortality caused by the decrease in another.

Rising sea levels and climatic extremes could result in a small proportion of those who may be displaced from their land in the Pacific and/or Asia seeking resettlement in Australia. Such environmental refugees would bring with them those infections found in their homelands. Some of these, without treatment, might have the potential to spread in Australia. Thus for both their benefit and the benefit of existing residents appropriate medical examination and care would need to be available to them on and after their arrival.

**Conclusion: Probable changes in incidence of some less common infectious diseases with overall implications to population health unlikely to be great.**

## 2. Heat related illness

The increase in death during heat waves is well documented in the USA and elsewhere (19). However, the mortality rate during heat waves varies across the USA, and appears to be dependent on the average summer daily temperatures and the amount of variation of summer temperatures. People living in places where the average daily temperature is higher, are less likely to die in heat waves than people living in places with lower average daily summer temperatures (19), presumably because of increased heat adaptation. Susceptibility to high temperatures increases with increased humidity and in urban densely populated areas, where heat retention results in higher minimum nightly temperatures (19). People do suffer from heat-related illness and mortality in Australia (20).

However, the evidence suggests that Australians are not particularly susceptible to heat waves, presumably because we have already adapted well to high summer temperatures. In most of Australia, the mortality in winter is higher than in summer months due to respiratory diseases including influenza. Therefore, it is difficult to predict whether, in the face of increases in temperatures of up to 6°C by 2100 (3;3;14), more people will die from heat-related illness than will not die due to a reduction in winter deaths (21).

**Conclusion: An increase in climate-related summer deaths and probable decrease in climate-related winter deaths.**

## 3. Health effects of extreme events

Climate change modelling for all countries predicts an increase in extreme events (flooding, cyclones/hurricanes, and heavy rain

events) (2). Australia is no exception, but coupled with these extreme events there is a probability of significant decreases in rainfall (2). This will increase the risk of bushfires, already a major problem in Australia (22).

The direct health effects of flooding, cyclones and bushfires will vary according to the degree of damage, the susceptibility of the populations and the ability of the population to obtain shelter. For flooding, disability or death can occur by drowning, injury, or electrical shock (23;24), in cyclones, from injuries by flying objects (24), and in bushfires from burns, injury and smoke inhalation. Careful planning and considerable improvement to infrastructure such as cyclone rating of houses to deal with more cyclones and ones that occur further south can reduce these health effects. Changes in building regulations in Southern Australia would be required to deal with the projected increase in mid-latitude storms, and changes in planning and building regulations to prevent bushfire damage and damage from flooding would also be required.

There are other health effects of extreme events. If there is displacement of a large number of people and disruption of infrastructure as a result of the extreme event, there is the potential risk of increased infectious diseases, although this is rarely experienced in Australia and other developed countries (23).

The mental health effects of surviving an extreme event, possibly losing loved ones, losing homes and possessions, and being displaced, can be significant and long lasting (23;25-31). This is becoming increasingly recognised as an important effect that requires both immediate and ongoing management such as counselling and other support.

The economic effects of drought, bushfires and other extreme events can be great, and this can have consequent health effects on the affected individuals and on the community. This is because it is well documented that people who are poor, displaced or unemployed have poorer health than those in the community who are relatively better off (32).

**Conclusion: The predicted increase in flooding, cyclones, drought and bushfires in Australia will have negative health impacts on the population. The extent of these impacts will depend on the degree of planning and mitigation.**

## 4. Climate change and its effect on air pollution and allergens

Air pollution is an important cause of morbidity and mortality in Australian cities (33-35), particularly through exacerbating respiratory disease, and reducing lung function in well individuals. Ozone is an important pollutant, and has been shown to be associated with respiratory disease in Brisbane, Melbourne and elsewhere (33-36), particularly among those who exercise outdoors or who have existing respiratory disease (37). It acts as a respiratory irritant, causing symptoms of both the upper and lower

respiratory tracts. While the effects of ozone on the health of people with existing lung disease is well documented, high ozone levels also causes respiratory symptoms among otherwise healthy people (38;39).

Although impacted upon by a number of factors, ozone levels increase with an increase in ambient temperature; particularly in settings with low levels of cloud cover (37). Therefore it is possible that in Australia, which will become hotter and drier as a result of global warming, could be particularly susceptible to the health effects of increased ozone pollution.

Warmer temperatures promote the growth of some plants and fungi known to be common causes of allergic symptoms (aeroallergens), particularly in the Northern Hemisphere. It has been speculated that global warming will result in an increase in aeroallergens and therefore in asthma and hay fever (3). The incidence of asthma does seem to increase in warmer climates in New Zealand (2;40), but we do not know why this is. While it is difficult to predict the impact of climate changes on asthma and hay fever in Australia, it is possible that there will be increased incidence of these conditions with warmer temperatures.

Increased aridity results in increased dust and can therefore result in increased dust-related illness. Dust plumes from inland Australia can pass over the populated coastal areas in Eastern Australia, and an association between dust events and asthma severity has been identified (41).

With Australia projected to become more arid as a result of global warming, dust related illness could increase. An increase in dust could also result in an increase in particulate-carried fungal spores, which may result in pulmonary and systemic fungal infections(41). However, this has not been a major health problem in Australia to date.

***Conclusion: Probable increases in air pollution and air pollution-related illness including due to increased dust. Effect on aeroallergens in Australia is unknown.***

## 5. Stratospheric ozone depletion

There continues to be some confusion between stratospheric ozone depletion and climate change, and certainly both are global man-made problems and there are links between the two problems. Stratospheric ozone depletion is occurring as a result of the release of chlorofluorocarbons into the atmosphere. In spite of reducing the level of chlorofluorocarbon emissions, ozone depletion is likely to continue, reaching a minimum during the first two decades of the twenty-first century (McMichael, AJ et al, draft). Global warming is likely to result in increased ozone depletion, as greenhouse gases trap warmth resulting in cooling of the outer stratosphere, which in turn results in an increased rate of ozone depletion (2).

Ozone depletion results in increased exposure to ultraviolet (UV) radiation. UV radiation causes skin damage and increases

susceptibility to skin cancers such as basal cell carcinomas and melanomas. Australia already has one of the highest rates of skin cancer in the world (42), and it is expected that the increased UV penetration resulting from ozone depletion will result in increased incidences of skin cancers and melanomas (43) as well as eye disease (44).

## 6. Reducing the health effects of climate change

Through careful planning and behavioural change it should be possible to minimise the health impacts of global warming. Vector control and behavioural change, by moderating exposure to mosquitoes, should maintain control over the incidence of vector borne disease. Careful food handling and the appropriate use of refrigeration should by controlling the levels of pathogens in food, continue to control food borne disease. Appropriate water treatment and the close monitoring of water quality should minimise the risk of waterborne disease.

The incidence of heat-related illness can be reduced through adequate housing (ventilation, insulation and shade), appropriate clothing, minimising outdoor activity during the hottest time of the day and by air conditioning. The health effects of extreme events, such as cyclones, can be minimised through careful mitigation, planning, and response. For instance for cyclones, mitigation includes the raising of public awareness, the implementation of stringent building codes, the upgrading and maintenance of existing structures, the planting of appropriate trees, the disposal or proper storage of potentially airborne materials and training and equipping of emergency workers. The effects of air pollution can be minimised by remaining indoors and by avoiding outdoor exercise when pollution is high. The ill effects of excessive UV due to ozone depletion can be minimised through the wearing of appropriate clothing, sunglasses and the use of sunscreens and shade.

Mitigation efforts are costly and will require considerable resources to implement. There is also a risk that they will not be performed in a uniform manner, thereby increasing the vulnerability of those who are already vulnerable.

While it is important to plan for and develop the infrastructure to mitigate the health effects of global warming in Australia, this does not supersede the priority of minimising the degree of global warming by reducing greenhouse gas emissions.

## 7. The health benefits of reducing greenhouse emissions

Increasing levels of carbon dioxide in the atmosphere is the most significant cause of global warming, and efforts to reduce levels of carbon dioxide emissions form the mainstay of mitigating climate change. Important sources of carbon dioxide include transport, with high rates of road freight and car usage,

high reliance on coal-fired power stations for electricity, and energy-intensive industries, all sharing responsibility (45). The combustion of fossil fuels also produces health-damaging particulate, volatile hydrocarbon and gaseous pollutants (amongst the latter nitrous oxide is in addition a potent greenhouse gas). Our small population compared to our land area obscures the fact that the majority of Australians live in cities and are therefore susceptible to the effects of urban air pollution (46).

All forms of carbon dioxide emission mitigation, whether they be activities that negate the demand for utility supplied energy (eg clothes line versus clothes dryer), make more efficient use of energy (eg fluorescent versus incandescent lighting), use non-polluting energy (eg wind versus coal generated electricity) or sequester carbon dioxide (eg revegetation) will moderate global warming and consequently the magnitude of the health ill-effects on the global population.

In addition to the above, certain behavioural changes (eg increased walking and cycling rather than car use) and industrial improvements (upgrading of equipment and improvements in processes) that mitigate greenhouse emissions would have direct benefits on the health as a consequence of increased exercise and/or of reduced exposure to environmental and/or occupational hazards. Although these effects are related to the process of mitigation rather than to the achievement of a moderated global warming, their benefits, particularly those related to increased exercise and reduced air pollution justify their discussion.

Australia's sprawling cities and transport policies have created an over-reliance on the car (47). The resulting lack of exercise is directly detrimental to health.

The most common cause of death in Australia is ischaemic heart disease with the second most common being cerebrovascular disease or stroke (48). While the death rate from these conditions has fallen in the past thirty years due to decreased smoking, control of blood pressure, control of dietary saturated fats and better disease management, (48), it would be possible to further reduce deaths through increased exercise and an associated reduction in obesity. Diabetes mellitus, particularly of adult onset, is the ninth most common cause of death in Australia, and is also a contributing factor in around nine percent of deaths due to ischaemic heart disease (48). Adult onset diabetes mellitus is largely preventable by an improved diet and exercise related weight loss.

'Burden of disease' is calculated from a consideration of both the deaths and disability caused. In Australia ischaemic heart disease, followed by stroke pose the greatest burden of disease. Diabetes mellitus is the seventh leading cause of burden of disease, and road traffic accidents the twelfth (48). Physical inactivity is a major determinant of ill-health in Australia, and is estimated to be responsible for about seven percent of the total burden of disease in Australia (48).

Prior to the post-war expansion of our cities and the growth in need and affordability of the private car, the proportion of jour-

neys made on foot or by bicycle was much higher. Thus there were more opportunities for exercise and obesity was less common (49). Road traffic accidents are the twelfth leading cause of burden of disease in Australia, and one of the most common causes of death in Australians from the age of one to 44 years (48). While death and disability due to road traffic accidents has decreased due to improved design of cars and roads, as well as the use of safety devices, the high level of car use contributes to this level of morbidity and mortality on the road. Reducing the level of motor vehicle use will result in reduced morbidity and mortality due to road traffic accidents.

The increased density of cars on the road decreases the safety, perception of safety and amenity for cyclists and pedestrians, thereby also decreasing the incentive for those except the most strongly motivated to use alternative modes of transport. The transport policies that have resulted in greater government subsidies for private motor vehicles compared to public transport, also reduces the incentive for the use of alternative means of transport and thus increasing car use (47).

Cars have become a necessary part of day-to-day life, particularly for people living in outer suburban areas where shops and business centres can be some distance away. This results in increasing social inequality for those individuals who cannot afford their own private motor vehicle, and also increases the chances that these individuals will use older, polluting and energy inefficient vehicles (47).

Social capital is becoming increasingly recognised as being an important contributing factor to the health of people in our community (48). Social capital results from actively participating in society, and from people interacting with each other. The increasing use of private cars decreases the opportunities for chance interactions, thereby decreasing inter-personal trust and therefore social capital. The increasing space occupied by roads decreases the amount of land available for public spaces, again resulting in decreased social capital.

The current policies that lead to excessive car use are not good for the health of our population, and yet there is little sign that policies in Australia will change radically as they must, in the foreseeable future. If Australia were to commit to reducing the level of carbon dioxide emissions, this would provide an excellent opportunity to institute policies to decrease the level of private car use, increasing the availability of alternative forms of transport, and thereby improving the health of our population.

Techniques for overcoming automobile dependence on cars are discussed in detail by Newman and Kenworthy (47). They describe the following five policies. "1. Traffic calming (to slow auto traffic and create more urban, humane environments better suited to other transportation modes). 2. Quality transit, bicycling and walking (to provide genuine options to the car). 3. Urban villages (to create multinodal centres with mixed, dense land use that reduce the need to travel and are thus linked to good transit).

4. Growth management (to prevent urban sprawl and redirect development into urban villages. 5. Taxing transport better (to cover external costs and to use the revenues to help build a sustainable city based on the previous policies).” There is an urgent need for widespread adoption of such policies in Australia.

Whilst all Australian cities have high levels of automobile dependence recent trends show some slowing in the rate of increase (47). This may be related to a reversal in the decline of inner-urban residential and commercial development with strong demand for housing close to rail services (eg Perth’s Northern Suburbs Rapid Transit System) (50).

The impact of air pollution on health has been discussed earlier in the context of increasing air pollution as a result of global

warming. On the other hand reducing carbon dioxide emissions provides an opportunity to simultaneously reduce the level of air pollution in our environment. Clearly, decreasing the levels of fossil fuel combustion for both transport and industry will decrease the emission of particulate, volatile hydrocarbon and gaseous air pollutants and therefore the levels of air pollution. During the 1996 Olympic Games in Atlanta, USA, the level of car use in Atlanta decreased by 22.5%, and the admissions to Emergency Rooms and hospitals for asthma decreased by 41.6% (51). Reducing the levels of air pollution in our cities will result in a direct improvement in health (33;52).

***Conclusion: Measures that reduce carbon dioxide emissions will have significant concomitant positive health impacts.***

## Conclusion

Global warming will have a major impact on human life in Australia, as well as on the lives of other animals and plants with which we share our land. In this paper we have attempted to specify the nature of the impacts on human health in Australia. On the whole these health impacts are a direct result of increased temperatures and the associated climate changes. There will be other considerable impacts of global warming on our country, such as on agriculture, water ways, and biodiversity, which will in turn have an impact on human health that is difficult to predict and to quantify. Good health as defined by the World Health Organization is not just the absence of disease but also having a subjective sense of positive well being, being capable of doing what we normally do, being adapted to our environment and feeling fulfilled (53). It is not possible to predict the impact of rapid climate change on these aspects of health.

Australia is fortunate in that, while the impact of global warming on Australia will be great, we are a wealthy country with the capacity to adapt to change and minimise the health impacts of global warming. Other countries, including some of our nearest neighbours will not be so fortunate, and as Pacific islands are inundated due to rising sea levels, and as parts of Asia increasingly find it impossible to sustain their population, Australia will feel the impact of the difficulties that our neighbours face. This will pose significant challenges for public policy and on our resources.

The impact of humans on our global environment is unprecedented. While humans have survived changes in climate before, never before has the rate of climate change been so great.

Coupled with this, we are living in a global environment that is rapidly being depleted of biodiversity, in which our water and soil quality is decreasing, our population is expanding, and the levels of toxins in our environment is increasing (4).

We will not be able to separate the health effects of global warming from the health effects of these other environmental changes. It is in the interests of us all to actively reduce these negative human impacts on our global environment. This can only be achieved through strong public policies in all countries, particularly the developed nations. This may well prove to be one of the greatest challenges ever to face the human race.

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