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The Effects of Climate Change on Public Health and the Healthcare Provider's Role in Addressing Climate Change

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HONORS RESEARCH PROJECT

“THE EFFECTS OF CLIMATE CHANGE ON PUBLIC HEALTH AND THE HEALTH CARE PROVIDER’S ROLE IN ADDRESSING CLIMATE CHANGE”

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Abstract

“Climate change is a term that refers to major changes in temperature, rainfall, snow, or wind patterns lasting for decades or longer. Both human-made and natural factors contribute to climate change” (EPA, p. 1, 2011). Some examples of human-made causes of global warming include burning fossil fuels (e.g., petroleum, coal, diesel), cutting down forests, and developing land for farms, cities, and roads, because these activities all release green house gases into the atmosphere. Green house gases are gases that trap heat in the atmosphere. There are some greenhouse gases such as carbon dioxide that occur naturally and are emitted into the atmosphere both through natural processes and human activities. Other greenhouse gases are created solely by anthropogenic causes and emitted into the atmosphere solely through human activities. (EPA, 2011) Some examples of natural causes of climate change include shifts in the Earth’s orbit, the sun’s intensity, the circulation of the atmosphere and oceans, and volcanic activity. (EPA, 2011) Greenhouse gases are necessary for life to exist on Earth because they trap heat in the atmosphere, which warms our planet and in a state of equilibrium. (EPA, 2011)

Significant changes are occurring on Earth due to global warming such as increasing ocean and air temperatures, widespread melting of snow and ice, and rising sea levels. Human beings are being exposed to climate change directly through shifting weather patterns such as more frequent and intense storms. Human beings are also being exposed to climate change indirectly through changes in water, air, food quality and quantity, ecosystems, agriculture, and economy. Climate change is not only affecting our environment but it is also expected to affect human health.

Social justice refers to the “fair distribution of society’s benefits, responsibilities and their consequences” (CNA, p.7, 2006). Developed countries benefit from the use of carbon-intensive technologies, while developing countries experience their consequences. It has been estimated that per capita emission of green house gases in the United States are seven times higher than in China, and 19 times higher than in Africa. (CNA, 2006) “Yet it is Africans and others in developing countries who bare the greatest burden of the reduced precipitation, diminished crop yields and flooding of low-lying areas that result from the changes in climate caused by these emissions” (CNA, 2006).

Nurses and other health care providers are qualified to bring information on climate change to the public because they have both the necessary scientific background and the communication skills to get the message across in an understandable way. (CNA, 2006) Their expertise in health promotion and behavior change also allows them to promote lifestyle choices that will decrease greenhouse gas emissions by individuals, families, and communities. My research paper will present the effects of climate change on public health globally, and the role nurses have to play in the adaptation and mitigation to climate change. By advocating for action to reduce societal inequities, strengthening public health infrastructure, and promoting behavioral strategies, nurses can proactively foster adaptations and mitigations to climate change.

Introduction

Climatological research over the past two decades has concluded that Earth's climate will change due to atmospheric greenhouse gas accumulation. (McMichael, 2006) "The Intergovernmental Panel on Climate Change (IPCC) forecasts an increase in world average temperature by 2100 within the range 1.4-5.8 degrees Celsius" (McMichael, p. 859, 2006). The IPCC predicts that the increase will be greater at higher latitudes and over land. Another finding the IPCC expects our planet to experience includes an increase in the global average annual rainfall. Many mid latitude and lower latitude land regions are predicted to become drier, whereas elsewhere precipitation events and flooding could become more severe. (McMichael, 2006) "Climate variability is expected to increase in a warmer world" (McMichael, p. 859, 2006). This unusually rapid temperature rise of 0.5 degree Celsius since the mid-1970s is significantly attributable to an increase in greenhouse gases from anthropogenic sources. (McMichael, 2006)

Today's climate-system models are much more comprehensive than in the 1990s, allowing us to learn much about how Earth's climate system responds to changes in natural and human generated effects: solar activity, volcanic eruptions, aerosols, ozone depletion, and greenhouse gas concentration. (McMichael, 2006) "Recent understanding of how sea surface temperature affects the characteristics of tropical storms and cyclones, and how ocean subsurface temperature, thermocline depths and thickness affect activity of the El Nino Southern Oscillation (ENSO) cycle, tropical cyclone intensification, and landfall predication will further enrich modeling capacity" (McMichael, p. 859, 2006). Today's models have been well validated against recorded data from past decades and indicate that Earth will continue to warm, with

associated increases in sea level and extreme weather events. (McMichael, 2006) “The IPCC reported that even if humankind manages to curb excess greenhouse gas emissions within the next half-century, the world’s oceans will continue to rise for up to 1000 years, reflecting the great inertial processes as heat is transferred from surface to deep water” (McMichael, p. 859, 2006). This is one of the anticipated outcomes for the future due to increased greenhouse gas and aerosol emissions. (McMichael, 2006)

Although today’s models have improved greatly from those utilized in the 1990’s, modeling cannot be an exact science. An uncertainty about modeling is evidenced by the sensitivity of the climate system to future atmospheric changes. (McMichael, 2006) “The range in the forecast increase in world average temperature (1.4-5.8 degrees Celsius) by 2100 indicates both uncertainty about future greenhouse gas emissions and marginal differences in design of the several leading global climate models (UK, Germany, USA, etc)” (McMichael, p. 859, 2006). Two more differences exist between the models, which include projected temperature and particularly rainfall changes. Therefore, estimates of climate changes over coming decades are considered indicative rather than predictive. (McMichael, 2006)

“The long-term good health of populations depends on the continued stability and functioning of the biosphere’s ecological and physical systems, often referred to as life-support systems” (McMichael, p.12, 2003). The importance of these life-support systems is not realized by the US and also many other societies throughout. This is due to our planet and human kind becoming increasingly urbanized and distanced from nature and its systems. (McMichael, 2003) The world’s climate system is an essential part of the life-support systems and is one of the many large natural systems that are being affected by increased human population, economic activities, and green house gas emissions. (McMichael, 2003)

“Traditional environmental health concerns long have been focused on toxicological or microbiological risks to health from local environmental exposures” (McMichael, p.13, 2003). In the early years of the twenty-first century, as human impact on the environment continues to alter the planet’s geological, biological and ecological systems, a range of larger-scale environmental hazards to human health is seen today. (McMichael, 2003)

According to author Anthony McMichael, the scale of environmental health problems has expanded from 1) household irritants (e.g.indoor air pollution), 2) neighborhood irritants (domestic refuse), 3) to community irritants (urban air pollution), 4) to regional (acid rain), to 5) global level (climate change). “This requires consideration of the ‘ecological footprint’ and how to decrease its size within the limits of global ecological sustainability” (McMichael, p.15, 2003).

Science of Climate Change

Climate change is defined as any change in global temperatures, precipitation (rainfall or snow), or wind patterns lasting for decades or longer over. (EPA, p. 1, 2011) Climate change is the result of both natural variability and human-induced contributions, the warming seen today cannot be explained by natural processes alone. (EPA, 2011) Some examples of human-made causes of global warming include burning fossil fuels (e.g., petroleum, coal, diesel), cutting down forests, and developing land for farms, cities, and roads, because these activities all release green house gases into the atmosphere. There are some greenhouse gases such as carbon dioxide that occur naturally and are emitted into the atmosphere both through natural processes and human activities. Other greenhouse gases are created solely by anthropogenic causes and emitted into the atmosphere solely through human activities. (EPA, 2011) Some examples of

natural causes of climate change include shifts in the Earth's orbit, the sun's intensity, the circulation of the atmosphere and oceans, and volcanic activity. (EPA, 2011) Greenhouse gases are necessary for life to exist on Earth because they trap heat in the atmosphere, which warms our planet and in a state of equilibrium. (EPA, 2011) Carbon dioxide is the most important anthropogenic greenhouse gas, produced by the burning of fossil fuels and also less often due to the changes in land use. Changes in land use have decreased the capacity of "carbon sinks," such as forests and soils, which absorb more carbon dioxide than they give off. (CNA, 2008) Although greenhouse gases can be produced by natural events, such as volcanoes and forest fires, the warming seen today cannot be explained by natural processes alone (EPA, 2011). "In the pre-industrial age, from AD 1000 to 1750, carbon dioxide levels increased from 275 to 285 parts per million, but over the next 250 years, up to 2005, they rose from 285 to 379 parts per million, primarily as a result of human activities" (CNA, p. 3, 2008). Thus the total greenhouse gas emissions to the environment have increased by 70% between 1970 and 2004 (CNA, 2008).

The United Nations Framework Convention on Climate Change (UNFCCC) has explained that climate change alters the composition of the global atmosphere, which is in addition to natural climate variability observed over comparable time periods. (CNA, 2008) These alterations in the global atmosphere were originally described as "global warming." The terminology has evolved because it has been realized that the warming of the earth results in a variety of changes in climate and is now termed "climate change." (CNA, 2008)

The amount of greenhouse gases being released into the atmosphere is increasing due to anthropogenic impacts (such as the burning of fossil fuels). (EPA, 2011) This increase in greenhouse gases being released into the atmosphere is warming the temperature of our planet and is resulting in a shift in the Earth's equilibrium. (EPA, 2011) Significant changes are

occurring on Earth due to climate change such as increasing ocean and air temperatures, widespread melting of snow and ice, and rising sea level. (EPA, 2011)

Global Changes in Climate

“Rising global temperatures and sea levels and declining snow cover over the past 150 years are the result of, and in turn contribute to, a number of long-term changes in climate, including increased arctic temperatures; widespread changes in precipitation amounts, ocean salinity and wind patterns; and more extreme weather events, such as droughts, heavy precipitation, heat waves and intense tropical cyclones” (CNA, p. 3, 2008). A specific example includes changes in precipitation amounts have caused desertification in the tropics and subtropics and flooding in parts of Europe. Changes in precipitation amounts have also contributed to an expansion in the ranges of insects and other disease-bearing vectors. (CNA, 2008)

The estimated rise in average world temperature over the coming century allows various important details to be concealed. “Anticipated surface temperature increases would be greater at higher latitudes, greater on land than at sea, and would affect the daily minimum night-time temperatures more than daily maximum temperatures” (McMichael, p.15, 2003).

For example, it is predicted that Alaska, northern Canada and northern Siberia could warm by approximately 5°C during the twenty-first century. Temperature increases that have already occurred above the Arctic Circle have disrupted polar bear feeding and breeding, the annual migrations of caribou, and also the network of telephone poles in Alaska, which were previously anchored in ice-like permafrost. Rainfall patterns are also predicted to change resulting in increases over the oceans but a reduction over much of the land surface. Rainfall events are predicted to intensify, resulting in more frequent, extreme events, thus increasing the likelihood

of flooding and droughts. Lastly, regional weather systems, including the great south-west Asian monsoon, could experience latitudinal shift. Change in world climate would influence the functioning of many ecosystems and the biological health of plants, animals, and humans. (McMichael, 2003)

Links between Climate Change and Human Health

Climate change is not only affecting our environment but it is also expected to affect people's health. Impacts on human health will vary geographically, as a function both of environment and topography and also, of the vulnerability of the local population. Impacts on human health are predicted to be both positive and negative, although expert scientific reviews anticipate predominantly negative impacts. (McMichael, 2003)

Direct Impacts on Health

Climate change may directly affect human health through increases in average temperature. An increase in average temperature may lead to more extreme heat waves during the summer while producing less extreme cold spells during the winter. (EPA, 2011) "In the United States, Chicago is projected to experience 25 percent more frequent heat waves and Los Angeles a four-to-eight-fold increase in heat wave days by the end of the century" (EPA, p.1, 2011). Populations that will be more vulnerable to these extreme heat waves include those with pre-existing cardio-respiratory diseases (such as asthma), the elderly, the very young, the homeless, and the urban poor. (EPA, 2011) An increase in intensity and in frequency of heat waves will be exacerbated by increased humidity and urban air pollution. (McMichael, 2003) "The greatest increases in thermal stress are forecast for mid to high latitude cities, especially in populations

with unadapted architecture and limited air conditioning” (McMichael, p.58, 2003).

Climatological modeling of heat wave impacts in urban populations suggests that many United States’ cities will experience, on average, several hundred extra deaths each summer.

(McMichael, 2003)

A relation between temperature and mortality has been predicted, varying by latitude and climatic zone. (McMichael, 2006) Populations living in hotter cities are more affected by colder temperatures, and populations living in colder cities are more affected by warmer temperatures. Also, regions in which housing provides poor protection against cold weather result in higher winter mortality than expected for that location. (McMichael, 2006) Research has revealed that in the UK and some other northern high-latitude countries, seasonal death rates and illness events are higher in Europe and North America. The results of this search have shown a positive association between heat waves and mortality, with elderly people. This is due to the elderly having a diminished physiological capacity for thermoregulation, especially women, being the most affected. (McMichael, 2006) The results concluded from other research have shown that mentally ill people, children, and others in thermally stressful occupations or with pre-existing illness are also vulnerable to heat waves. Majority of deaths due to heat waves occur in individuals with pre-existing cardiovascular disease, such as a heart attack or stroke, or in individuals with chronic respiratory diseases, such as asthma. (McMichael, 2006)

An increase in frequency of extreme events such as storms, floods, drought and cyclones would harm human health in many different ways. An increase in frequency of extreme weather events could cause direct loss of life and injury. It could also affect the health of human beings indirectly through a variety of ways including: loss of shelter, population displacement, contamination of water supplies, loss of food production (leading to hunger and malnutrition),

increased risk of infectious disease epidemics, and damage to infrastructure for provision of health services. (McMichael, 2003)

The more direct impacts on health due to an increase in intensity and frequency of weather events include those due to changes in exposure to weather extremes. Examples of these weather extremes include heat waves, floods, cyclones, storm-surges, and droughts. An increased production of certain air pollutants and aeroallergens, such as spores and moulds are predicted to develop due to an increase in intensity and frequency of weather events. (McMichael, 2006)

Some health consequences due to extreme weather events arise during or soon after the event. In the case of a flood, injuries, communicable diseases, or exposure to toxic pollutants occur soon after the event. Consequences of a flood that result later on are malnutrition and mental health disorders. Another extreme weather event that will have significant consequences to human health is excessive rainfall. (CNA, 2008) This is because excessive rainfall facilitates the entry of human sewage and animal wastes into waterways and drinking water supplies, potentiating water-borne diseases (McMichael, 2006). “The World Health Organization estimated that in the year 2000 climate change was responsible for 154,000 deaths and 5.5 million disability- adjusted life years (DALYs) through diarrheal disease, malaria, fatal unintentional injuries related to coastal and inland flooding, and malnutrition, mostly in low-income countries” (CNA, p.4, 2008). Although excessive rainfall and floods have a tremendous affect on human health, it is predicted that globally, disaster effects are greatest for droughts, with associated famines, because of their regional extent. (McMichael, 2006)

Indirect Impacts on Health

Changes in the air, water, and ecosystems due to climate change will act less directly to affect humans by increasing the risk of infectious diseases, especially water, food and vector-borne diseases, and regional food productivity, specifically cereal grains. (McMichael, 2003) In particular, are diseases that appear in warm climate locations and are spread by mosquitoes and other insects. Examples of these vector-borne diseases include malaria, dengue fever, yellow fever, and encephalitis. (McMichael, 2003)

The transmission of infectious disease is determined by many factors, including social, economic, climatic, ecological conditions, and human immunity. (McMichael, 2006) Increased temperature has an effect on many infectious agents, vector organisms, non-human reservoir species, and on the rate of pathogen replication. “Both salmonella and cholera bacteria, for example, proliferate more rapidly at higher temperatures, salmonella in animal gut and food, and cholera in water” (McMichael, p. 862, 2006). In areas in which factors such as, low temperature, low rainfall, or the absence of vector habitat restricts transmission of vector-borne disease, climatic changes could tip the ecological balance and trigger epidemics. (McMichael, 2006) Many research studies have shown that an increase in ambient temperature would cause worldwide, net increases in the geographical distribution of some vector organisms, such as malarial mosquitoes. “Further, temperature related changes in the life-cycle dynamics of both the vector species and the pathogenic organisms (flukes, protozoa, bacteria and viruses) would increase the potential transmission of many vector-borne diseases such as malaria (mosquito), dengue fever (mosquito) and leishmaniasis (sand-fly)—although schistosomiasis (water-snail) may undergo a net decrease in response to climate change” (McMichael, p.22, 2003)

The geographical range and seasonality of transmission of many vector borne diseases will change due to higher temperatures, changes in precipitation and climate variability. The majority of changes will occur to the range and seasonality of transmissions, in which the seasonality will be extended in some areas, and reduced in other areas. (McMichael, 2003)

Climate change will decrease the likelihood of transmission because of a reduction in rainfall, or temperatures that are too high for transmission for some vector-borne diseases in certain locations. Malaria is becoming more of an epidemic in our world; currently 40% of the world population lives in areas in which endemic malaria occurs. Endemics of malaria are predicted to increase even more due to higher temperatures, in combination with increased rainfall, and surface water. These climatic changes will extend the transmission season of malaria in some locations. Many other vector-borne infections, such as dengue, leishmaniasis, Lyme disease, and tick-borne encephalitis would also be effected at the margins of their current distributions due changes in climate conditions. (McMichael, 2003) “A range of mathematical models, based on observed climatic effects on the population biology of pathogens and vectors, indicate that climate change scenarios over the coming century would cause a small net increase in the proportion of the world population living in regions of potential transmission of malaria and dengue” (McMichael, p.60, 2003).

An increase in heavy rainfall events allows transportation of terrestrial microbiological agents into drinking-water sources. This results in outbreaks of cryptosporidiosis, giardiasis, amoebiasis, typhoid and other water-borne infectious diseases. (McMichael, 2003)

“Epidemiological evidence has pointed to a widespread environmental cause for recent outbreaks of cholera, rather than a point source contamination as seen in Peru in 1991 and East Africa in 1997/98” (McMichael, p.60, 2003). There have also been results showing strong links between

cholera infections and bathing and drinking water from east African lakes. (McMichael, 2003)

Cholera epidemics are also correlated with positive surface temperature irregularities in coastal and inland lake waters. Another water-borne infectious risk due to climate change that is expected is from changes in the marine environment. Alterations in the marine environment will alter risks of bio-toxin poisoning from human consumption of fish and shellfish. (McMichael, 2003) “For example, bio-toxins associated with warm waters, such as ciguatera in tropical waters, could extend their range to higher latitudes” (McMichael, p.60, 2003). The incidence of diarrheal diseases is likely to increase due to these changes in surface water quality and quantity. Diarrheal diseases are conditions caused by bacteria such as cholera and typhoid, which are dependent on the concentration of the pathogens in water or food. (McMichael, 2003) Climate can affect the bacteria of cholera and typhoid by increasing “directly the amount of pathogen in the water through increasing the biotic reservoir of the infectious agent (cholera) or by decreasing the amount of water in a river or a pond and thus raising concentration of the bacteria (typhoid)” (McMichael, p.60, 2003). Diarrheal diseases are conditions also caused by parasitic diseases such as amoebiasis, giardiasis and cryptosporidium. An increase in floods as a result of climate change can cause contamination of public water with both bacteria and parasites as surface water discharge flows into rivers and reservoirs, while drought can increase the concentration of pathogens in the limited water supplies. (McMichael, 2003) “Currently the World Health Organization (WHO) estimates more than one billion people worldwide to be without access to safe drinking water, and that every year approximately 1.7 million die prematurely because they do not have access to safe drinking water and sanitation” (McMichael, p.60, 2003). These effects of a reduction in the availability of clean water includes an increase

in the risk of drinking contaminated supplies and also a reduction in the amount of water available for personal hygiene, thus leading to skin infections. (McMichael, 2003)

Climate change will have effects on food production globally. Most of the research on this public health risk has focused on cereal grain production. Cereal grain production is an important indicator of total food production because it accounts for around 70% of global food energy. (McMichael, p.59, 2003) “The probability of reduced food yields is, in general, greatest in developing countries where it is estimated that approximately 790 million people currently are undernourished” (McMichael, p.59, 2003). The results of modeling studies used to estimate the impacts of climate change upon cereal grain yields show that globally, a slight downturn appears likely but this would be greater in already food insecure regions in south Asia, parts of Africa and Central America. (McMichael, 2006) Other populations that will be particularly vulnerable to local decreases or disruptions of food supply are isolated areas with poor access to food markets. (McMichael, 2003) This would increase the number of malnourished people tremendously in the world. The secondary effects due a decrease in cereal grain production include conflicts and migrant and refugee flows. Conflicts and migrants and refugee flows would then typically increase infectious diseases, malnutrition, mental health problems, and injury and violent death. (McMichael, 2006)

The impacts of climate change may cause severe social disruptions, local economic decline and population displacement that would affect human health in some areas of the world. (McMichael, 2003) “Of particular concern is the impact of a rising sea level (estimated, with a wide band of uncertainty, at around 0.5m over the coming century) on island and coastal populations currently living not far above the shoreline” (McMichael, p. 63, 2003).

Assessments of Health Impacts by Region

Climate-sensitive diseases that will prominently affect Africa include malaria, meningitis, and cholera. (McMichael, 2003) “Malaria epidemics in the past 15 years have been reported mainly in the highlands of east Africa, Rwanda and Zimbabwe, associated with inter-annual climate variability (such as the occurrence of El Niño events)” (McMichael, p. 62, 2003).

Malaria outbreaks were reported in the regions of Somalia and Kenya following flooding caused by the El Niño event in 1997/98. The 1997/98 El Niño event also provided favorable factors for cholera epidemics to occur in Djibouti, Somalia, Kenya, Mozambique and the United Republic of Tanzania. This was due to the rise in sea-surface temperature and excessive flooding.

(McMichael, 2003) It has been concluded that a significant association between bathing and drinking water from Lake Tanganyika and the risk of infection with cholera exists. The cause of this is most likely due to warming in these African lakes, which then cause conditions that increase the risk of cholera transmission. Plague outbreaks in Africa have also been reported in the last few years in Mozambique, Namibia, Malawi, Zambia and Uganda. (McMichael, 2003)

In Asia, as in Africa, the main public health risk due to climate change and variability are malaria and cholera. Thermal stress and air-pollution related illnesses also projected to occur in Asia. (McMichael, 2003) “Malaria still is one of the most important vector-borne diseases in India, Bangladesh, Sri Lanka, Thailand, Malaysia, Cambodia, the Lao People’s Democratic Republic, Viet Nam, Indonesia, Papua New Guinea and parts of China” (McMichael, p. 62, 2003). In many south Asian countries, water-borne diseases such as cholera, and diarrheal diseases such as giardiasis, salmonellosis and cryptosporidiosis, are presently affecting individuals whom are drinking contaminated water. As the temperature of the climate increases, these diseases could become more frequent in many parts of south Asia. A warmer climate will

also cause direct effects on human health in this region due to heat waves (increasing incidence of heat strokes). (McMichael, 2003) “The heat index (derived from daily mean temperature, and humidity) is closely related to the occurrence of heat stroke in males aged 65 years and above residing in Tokyo” (McMichael, p. 62, 2003).

The number of heat waves will increase in Australia due to climate change. This will cause many health issues including heat strokes and acute exacerbations of already existing respiratory illnesses will occur (ex., increase in asthma attacks). Increases in infectious diseases have also been reported in recent years in Australia and also in New Zealand. (McMichael, 2003) The number of notified cases of arbovirus infections (caused by insect-borne virus) has increased in Australia. The Ross River virus disease and Murray Valley encephalitis in southeastern Australia have also been associated to follow heavy rainfall events. In New Zealand, “exotic species such as *Aedes albopictus* and *Aedes camptorhynchus*, competent vectors of (respectively) the dengue and Ross River viruses have been detected” (McMichael, p. 64, 2003).

The major impacts on health in Europe are mainly due to thermal stress and air pollution, vector and food-borne diseases, water-related diseases and flood effects. (McMichael, 2003) It is predicted that because of deteriorating health care systems in Europe, the recent resurgence of malaria in southeastern Europe could increase from a warmer climate. (McMichael, 2003) Presently, there are a small number of locally transmitted cases in the Mediterranean region of Europe. “However, existing public health resources and reduction of breeding habitats for *Anopheles* mosquitoes make it unlikely that malaria will re-emerge on a large scale in western Europe, whatever changes take place in the climate” (McMichael, p. 64, 2003). Lyme disease and tick-borne encephalitis (TBE) are transmitted by ticks that live in the temperate regions of Europe. Studies in Sweden suggest that the incidence of TBE has increased following milder

winters, in combination with an extended spring and autumn for two successive years.

(McMichael, 2003) “Climate change may extend the tick-borne disease transmission season and also its range towards the north, but disrupt transmission in more southerly regions”

(McMichael, p. 65, 2003).

The regional assessment of health impacts in the Latin America indicate that the main concerns are heat stress, malaria, dengue, cholera and other water-borne diseases. Latin America has also been particularly affected by extreme weather events, especially those associated with the El Niño event in 1997/98. (McMichael, 2003) Rainfall has been observed to cause outbreaks of bubonic plague in semi-arid zones in Mexico. This is probably as a result of an increase in the rodent reservoirs. In Colombia, rodents escaping floods are suspected to have been the primary cause of leptospirosis outbreaks. The effects of water-borne diseases are well established in Latin America. (McMichael, 2003)

“The direct impacts of climate change and variability in North America include heat stress, injury and mortality due to convective storms, floods, hurricanes, tornadoes and ice storms” (McMichael, p. 66, 2003). It is unclear precisely what effect climate change will have on urban air quality in North America, but it is known that higher temperatures increase the risk of significant photochemical smog. (McMichael, 2003) In the United States, the most frequent leading cause of death from natural disasters is floods. The mean annual loss of life in the US from floods has been estimated to be 147 deaths. (McMichael, 2003) “The areas of the United States most vulnerable to heat-related illnesses appear to be the north-east and mid-west” (McMichael, p.66, 2003). However, if warmer winters are to occur, this could result in fewer cold related deaths. “The frequency of natural disasters may also be increasing in the United States” (McMichael, p.66, 2003). This is evidenced by less than 20 natural disasters being

reported annually in the 1950s and 1960s, but more than 40 per year being reported in the 1990s. Several vector-borne diseases are endemic in North America. There are several climate sensitive vector-borne diseases in the United States, which include the following: Lyme disease, Rocky Mountain spotted fever, St Louis encephalitis (SLE), western equine encephalitis (WEE) and snowshoe hare virus (SHV). (McMichael, 2003)

Adaptation to and Mitigation of Climate Change

Adaptation to climate change has been defined as “an adjustment in human systems in response to actual or expected climatic stimuli or their effects, which reduces the associated risks to population health through preventive measures” (CNA, p.7, 2008). In order to assess the health impacts of, and vulnerability to, climate change, it is essential to consider adaptation. (Pew Center, 2011) The vulnerability of a population depends on factors such as population density, level of economic development, food availability, income level and distribution, local environmental conditions, pre-existing health status and the quality and availability of public health care. (CNA, 2008) Improvements in these areas will increase adaptive capacity to climate change and will also provide other benefits to these populations, regardless of future changes in climate. Reducing income and education inequities, ensuring the availability of appropriate housing and making sure that no particular group falls behind the rest of the country in economic development are key strategies in promoting adaptation to climate change. At the international level, development funding can increase the capacity of populations to adapt to climate change by strengthening public health systems, improving economic development and increasing access to education (CNA, 2008). “Adaptation can be undertaken at the international/national, community and individual level—that is, at macro, meso and micro-levels” (McMichael, p. 24, 2003).

Adaptive actions to reduce health impacts from climate change are considered in terms of the conventional public health categories: primary, secondary, and tertiary prevention. (Pew Center, 2011) Primary prevention is an intervention implemented before there is evidence of disease or injury, such as avoiding hazardous exposure or removing causative risk factors. Bed nets can be supplied to populations at risk of exposure to malaria as primary prevention. Another example of primary prevention includes early warning systems (such as extreme heat warnings and famine early warning) to provide information on hazards and recommended actions to avoid or reduce risks. (Pew Center, 2011) Secondary prevention is an intervention implemented after a disease has begun, but before it is symptomatic (such as early detection or screening measurements) and subsequent treatment that averts full progression to disease. Examples of secondary prevention specific to climate change include enhancing monitoring and surveillance, improving disaster response and recovery, and strengthening the public health system's ability to respond quickly to disease outbreaks. Lastly, tertiary prevention is an intervention that attempts to minimize the adverse effects of an already present disease or injury (such as better treatment of heat stroke and improved diagnosis of vector-borne diseases). (Pew Center, 2011)

Although climate impact studies consider adaptation, they rarely do more than identify potential adaptation options or model them in a simple way. It is necessary for research to be conducted on the dynamics and processes of adaptation decision-making, including the roles and responsibilities of individuals, communities, nations, institutions and the private sector. (Pew Center, 2011)

“Mitigation of climate change refers to reducing green house gas emissions to reduce the hazard” (CNA, p.8, 2008). This means reducing the consumption of fossil fuels we use and

promoting forestry and agricultural measures that increase the uptake of carbon dioxide by carbon sinks. (CNA, 2008) According to Canadian Nurses Association, “the extent to which society is willing to expend resources to avoid the effects of climate change will depend in part on its perceptions of the risks posed by climate change, the perceived costs of the effort, ability to pay, and how much it is willing to risk possible negative consequences” (CNA, p. 8, 2008). The ultimate goal of mitigation is stabilization, which “requires that annual emissions be brought down to the level that balances the Earth’s natural capacity to remove the greenhouse gases from the atmosphere” (CNA, p. 8, 2008). An absolute worldwide reduction in green house gas emissions is necessary within the context of growth in GDP and population worldwide in both developed and developing countries in order to achieve this goal. Identified strategies have been identified that could be undertaken by various sectors of the economy (including energy supply, transport, buildings, industry, agriculture, forestry and waste) to reduce green house emissions. Some of these strategies include the use of new technologies, such as fuel-efficient cars and lighting, while others are intended to increase the effectiveness of carbon sinks. (CNA, 2008) “Although most of the strategies proposed will save money in the long term, they all require up-front investments, which are often costly and will thus reduce short-term profitability” (CNA, p.8, 2008). The use of policy tools will be required in order to increase the likelihood that the industrial and manufacturing sectors will make these types of investments. (CNA, 2008) Policy tools to support industrial, manufacturing and other sectors as they make investments to reduce their overall emissions include the following:

“1) Regulations and standards on levels of emissions offer some certainty and predictability in business planning.

- 2) Tradeable permits can be used within a cap-and-trade systems. In this type of system, a total emissions level (or cap) is established for a sector, and the cap is divided into individual permits, which are distributed to the plants or units within that sector. The permits can be sold, which means that a plant that does not have a permit large enough for the emissions it produces can either pay for the technology to reduce its emissions to buy additional emissions permits from others in the same sector. In theory, this system assigns a cost to emissions, which fosters investment in technology to reduce them.
- 3) Financial incentives can also be used to encourage businesses, industries, and consumers to adopt more energy-efficient technology.
- 4) Taxes on emissions can set a price for carbon but cannot guarantee a particular level of emissions, as some businesses may choose to pay the tax rather than take the potentially more costly step of investing in energy efficiency.
- 5) Voluntary emissions agreements between governments and industries generally have not been effective, largely because energy efficiency is costly, and it is difficult to convince businesses to reduce their profits in the absence of a regulatory framework.
- 6) Information instruments or awareness campaigns may be effective in contributing to behavioral change; however, their impact on emissions has not yet been measured.
- 7) Research and development can stimulate technological advances to support increased energy efficiency” (CNA, p. 8, 2008).

Nursing's Role in supporting Adaptation to and Mitigation of Climate Change

Over the past decade, several authors have proposed that nurses become involved to help support adaptation to and mitigation of climate change. In an editorial published in *Nursing Ethics*, the author urged professional associations to engage in the climate change discourse as a “matter of urgency.” The author proposed that nurses prepare policy documents on the impact of climate change on nursing, advocating for mitigation of the impact of industry and other economic activity on the environment, and including climate change and health in nursing curricula. The author of *Revolution: The Journal for RNs and Patient Advocacy*, proposed that health care professionals should be involved in educating the public about global warming and should support mitigation measures. (CNA, 2008) “In addition, in an editorial in a community nursing journal published in the United Kingdom, stressed the importance of nurses engaging in the climate change debate as part of their role in advocating for the vulnerable” (CNA, p. 1, 2008).

Nurses are uniquely qualified to bring information on climate change to the public because they have both the necessary scientific background and the communication skills to get the message across in an understandable way. (CNA, 2008) “Their expertise in health promotion and behavior change also equips them to foster lifestyle choices that will decrease greenhouse gas emissions by individuals, families, and communities” (CNA, p.1, 2008).

Advocating for action to reduce societal inequities, strengthening public health infrastructure and promoting behavioral strategies that foster adaptation to climate change are all roles nurses are capable of contributing to. (CNA, 2008) Nurses promote positive adaptations to major life changes to individuals, such as with the birth of a child or the diagnosis of a chronic illness. Community health nurses have also worked with others to increase community capacity

to address various stressors. (CNA, 2008) “This same expertise can be used to support adaptation to climate change in a way that promotes and maintains the health of individuals, families, and communities” (CNA, p.1, 2008).

Nurses can play a major role in emergency planning/preparedness for climate changes, including involvement of nurses at all levels of government planning. Other ways in which nurses can contribute to adaptation to climate change includes develops warning systems for upcoming heat waves through the public health department. (CNA, 2008) Nurses can educate the public about protective technologies such as sunscreen, air conditioning, urban planning, and re-engineer water systems. Lastly, nurses can caution the public about upcoming treacherous weather, about considering the Air Quality Index (AQI) in outdoor activities, and to be aware of changes in patterns of disease. (CNA, 2008)

There are many roles nurses can play in the mitigation to climate change. “Nurses can act on climate change by providing a handout on the subject as part of discharge planning, mentioning climate change and what can be done during prenatal classes, raising the issue at team or staff meetings, joining the workplace health and safety committee to support operating choices that lower GHG emissions, sitting on urban planning committees to reduce the trend to development of suburbs and exurbs and becoming involved in climate change discussion in their communities” (CNA, p.9, 2008). It is important to stress to their patients and the public that many consumer choices intended to produce fewer green house gases are also good for health. (CNA, p.9, 2008) “For example, walking or biking to work rather than driving promotes cardiovascular fitness, driving at the posted speed limit is safer than speeding, and insulating homes properly means mould is less likely to grow” (CNA, p.9, 2008).

Policy

The crucial challenge our planet is currently experiencing is to reduce greenhouse gas emissions by a sufficient amount in order to prevent destruction of the climate system. (McMichael, 2003). There are national governments, such the UN Framework Convention on Climate Change (UNFCCC), that are committed in principle to seeking this outcome. (McMichael, 2003) Although, preventing the destruction of the climate is proving difficult to find a politically acceptable course of action, often because of apprehensions about possible short-term economic consequences. (McMichael, 2003)

It is necessary for nurses to be contributing to policy changes on climate change. (CNA, 2008) Nurses can play a significant role in influencing policy changes related to climate change by:

- “-encouraging their professional associations to support policy efforts to reduce green house gas emissions
- working with coalitions of non-governmental organizations on measures to reduce green house gas emissions
- absolute cap on emissions versus reducing their intensity
- carbon taxes to increase the costs of energy (and support reduced use)
- Leadership by developed world versus BAU (Business As Usual) until developing world signs on to targets” (CNA, p.10, 2008).

Conclusion

Our actions today may jeopardize the well-being and health of future generations because green house gases, such as carbon monoxide, can remain in the atmosphere for decades to many centuries after they are emitted. (Pew Center, 2011) The process of sea level rise is already occurring that will continue for many centuries as the extra heat trapped at Earth's surface by the human-amplified greenhouse effect progressively enters the deep ocean water. (Pew Center, 2011) "Similarly, it is likely that the continuing rapid extinction of populations and species of plants and animals will leave a biotically impoverished, less ecologically resilient and less productive world for future generations" (Pew Center, p. 13, 2011).

Nurses face a very real choice between getting involved now in promoting adaptation to and mitigation of climate change instead of waiting until they face increasingly severe health effects on the individuals, families, and communities with whom they work. Nurses, with their long history of focusing on the needs of individuals, families and communities, represent a trusted source of information, which will assist them to support adaptation to and mitigation of climate change. As a profession, nurses can, and should, make efforts to support the types of policy instruments and lifestyle changes that will reduce green house gas emissions and improve the health and wellbeing of individuals globally over the long term. (CNA, 2008)

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