

Climate Change: A Review of Potential Health Consequences

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Abstract

The Intergovernmental Panel on Climate Change (IPCC) recently released its latest report, Climate Change 2014: Impacts, Adaptation, and Vulnerability (IPCC, 2014). This report provides evidence of the recent changes in the world's climate and the impact of these changes on the environment and human systems. The IPCC report indicates the continued warming of the climate is projected to increase the risks to humans associated with air pollution and decrease in the atmospheric ozone layer, severe weather events due to ocean storms, increased precipitation or drought, extreme heat events, and changes in animal, fish, and insect habitats, all with potential health consequences to humans.

Keywords: Health consequences; Climate; Pollution; Ozone

Introduction

On a global level, food and water availability/scarcity may lead to population migration and governmental conflict further increasing the risk of human health consequences [1]. As advanced practice nurses, we must be aware of the human health risks associated with climate change and educate our clients. We must identify those clients we care for with increased vulnerability - the young, the old, individuals with chronic health conditions, and those living on the margins of society due to poverty, lack of health care coverage, immigration status, language barriers, homelessness or mental illness - and provide them with anticipatory education regarding these risks and identify available community health services to assist them when needed.

In 2014, the Third National Climate Assessment report [2] was released. Although focused on the impact of climate change in the United States, the health implications are applicable to all people. The majority of the world's population will feel the impact of climate change but health effects will be variable in severity and frequency based on geographic location, the local disruptions of the physical, biological, and ecological systems, the resilience of critical public health infrastructure, and the vulnerability of the people in the region [2].

Health Consequences of Changing Air Quality

Air Pollution

Climate change is projected to harm human health by increasing air pollution, especially through increased small particulate matter pollutants in the air and chemicals trapped in the atmosphere by increasing ground-level ozone, commonly referred to as smog. The United Nations Environmental Programme (2014) states air pollution is the world's worst environmental health risk resulting in increased incidence of stroke, heart disease, lung cancer, chronic and acute respiratory disease, including asthma. The United Nations estimates 3.5 million people die each year from outdoor air pollution. In October 2013, the International Agency for Research on cancer

(IARC), part of the World Health Organization (WHO), announced that air pollution was a cancer-causing agent [3].

Small size particulate air pollutants are easily inhaled into the lungs of those exposed; the smaller the particulate matter in size, particulate matter 2.5 micrometers or less in diameter are especially harmful, the further down into the lung fields the pollutants can travel [2,4]. Sources of particulate matter include automobiles, industrial pollution, power plant emissions, especially coal burning plants, home cooking and heating with solid fuels such as wood, and burning of municipal waste and agricultural residue [5]. Purposeful landscape fires, a common means of clearing vegetation in many countries, also contributes to air pollution and is estimated to cause more than 250,000 deaths per year [6]. Regional droughts as a result of long periods of record heat and limited precipitation, such as are currently occurring in the Western United States, have increased the risk of major forest fires. Smoke from these wild fires contains abundant particulate matter, carbon monoxide, and various volatile organic compounds, precursors to ozone and smog, which are spread over major areas downwind of the fires resulting in increased incidence of asthma exacerbation and respiratory illness [7].

Increased ozone exposure and particulate matter in the air has been associated with increased susceptibility to cardiovascular and respiratory conditions, medication use, and health care visits, including emergency room visits and hospital admissions in the United States [2,8]. Air pollution has even been associated with an increase in premature births and decreased lung development in children exposed to repeated fine particulate matter in the air and increased ozone levels [9-11].

Airborne Allergens

The World Health Organization (WHO) estimates 235 million people currently have asthma and an estimated 25-40% of people experience some form of allergy, often associated with allergic pollen in the air (WHO and World Meteorological Organization [WMO], 2012). Warming temperatures result in more frost-free days and prolonged flowering time and pollen initiation from allergic plants [2]. Higher pollen concentrations and longer pollen seasons increase

allergic symptoms and asthma exacerbations in exposed individuals [12,13].

In addition, extreme rainfall in certain regions and rising temperatures increases the growth of molds and fungi. The Institute of Medicine of the National Academies (IOM)[15] released a report in 2011 titled *Climate Change, the Indoor Environment, and Health* (IOM, 2011) [16]. The report concludes that climate change influences the indoor air quality through migration of polluted air indoors as well as dampness, moisture, and flooding associated with excessive precipitation causing conditions that encourage the growth of mold, fungi, and bacteria in indoor living spaces. Individuals with allergies are particularly susceptible to these indoor allergens [14].

Extreme Weather Event and Human Health

Hurricanes and Typhoons

Climate change and warming of the oceans increases the risk of larger, stronger hurricanes and typhoons (IPCC, 2007). Hurricane Katrina in September 2005, resulted in the deaths of over 1400 people; two-thirds either drowned or died from illness or injury because they were trapped by flood waters [17]. Even the major medical centers in New Orleans were unable to function due to rising waters and loss of electricity. The primary risks to people during these extreme weather events are trauma and drowning. But the risks associated with a failed infrastructure that often follows an extreme weather event - the loss of medical services, lack of potable water, sanitation, electricity, food and shelter - compound the health risks and may take weeks to months to re-establish.

The IPCC [18,19] projects that heavy rainfalls and maximum wind speed with tropical cyclones are likely to increase with continued global warming but that it is likely that the global frequency of tropical cyclones will either decrease or remain unchanged. It is hard to predict the frequency of hurricanes and typhoons but there is concern that due to the warmer ocean temperatures, those storms that are created will be stronger with the potential to inflict greater structural and environmental damage, human mortality and morbidity. The United States Third National Climate Assessment report [2] states the intensity, frequency, and duration of North Atlantic hurricanes, as well as the frequency of the strongest hurricanes, have all increased since the early 1980s and they project hurricane intensity and rainfall will increase as the climate continues to warm. The rising sea levels associated with global warming have increased the hazards of flooding from tidal surges associated with storms [19]. This occurred with Hurricane Sandy in the Northeast United States in 2012 and Typhoon Haiyan in the Philippines in 2013. Hurricane Sandy resulted in the deaths of 285 people and economic costs estimated at \$65 billion (Rice, 2013), while Typhoon Haiyan killed over 6000 people and injured innumerable others, devastating the city of Tacloban, Philippines.

Extremes in Precipitation

Flooding from excessive precipitation also causes drowning and physical trauma from flood waters, loss of safe shelters, mud slides, and prolonged increased morbidity and mortality due to damaged infrastructure. Excessive precipitation also increases the risk of water- and vector-borne infectious diseases [2,16,20]. Diarrheal diseases due to contaminated water from flooded septic systems can occur even in developed countries with normally adequate septic systems [21]. Standing water and warm temperatures are ideal breeding grounds for

mosquitos that may increase disease burden in humans. Diseases such as West Nile virus, malaria, Dengue Fever, and Chikungunya have become more widespread in Central America and the United States [22]. Tick-borne diseases such as Lyme disease, Rocky Mountain spotted fever, anaplasmosis and babesiosis have also spread over greater regions of the United States but the affect of climate change on the spread of tick-borne conditions is unknown [23,24].

The IPCC (2014) reports the percentage of the global population experiencing water scarcity and the percentage experiencing major river floods are expected to increase over the 21st century. The United Nations Department of Economics and Social Affairs (2014) reports that the scarcity of water already affects regions of every continent and over 1.2 billion people, almost one-fifth of the world's population, live in regions that lack the necessary infrastructure to make use of water from rivers and aquifers. This critical lack of accessible water has far reaching affect on human health. The United Nations Department of Economic and Social Affairs [25] indicates lack of access to safe, fresh, adequate water supplies for consumption, hygiene, sanitation, and livestock and agricultural use, impedes the attainment of seven of the eight Millennium Development Goals. Prolonged droughts associated with climate change cause food shortages leading to malnutrition that increases morbidity and mortality, especially in South Asia and sub-Saharan Africa [26]. Unfortunately, in recent years, many of the countries experiencing severe droughts are also experiencing political unrest further compromising the ability of the country's health care system to provide care to the people. Populations experiencing severe drought and food scarcity often migrate to other areas in search of water and food, increasing stress on neighbouring countries and global political unrest [27]. Climate change is increasing the scarcity of water. The United Nations Development Programme document, *Beyond Scarcity: Power, Poverty and the Global Water Crisis* [28], reports on the importance of water for human consumption, sanitation, agriculture and livestock production, and how the inequity of water resources around the world poses potential major geopolitical crises.

Droughts decrease the air quality and can spread fungal pathogens such as coccidioidomycosis and even some vector-borne conditions such as hantavirus found in rodents in dry arid regions [29,30]. Of particular concern is the regular epidemic of *Neisseria meningitidis* that occurs from December to May, in sub-Saharan Africa (WHO and WMO, 2012). There is a clear temporal association between meningitis cases and the dry, hot and dusty climate during these months in the area affected. It is unknown whether further climate change will be associated with increased cases of meningitis. An active preventative public health vaccination strategy with a meningitis. A conjugate vaccine has been implemented to help stem this annual epidemic (WHO and WMO, 2012).

Extreme Heat Events

The IPCC reports [18,31] indicate substantial warming in temperature will occur by the end of the 21st century. Extreme heat events, unusually hot weather conditions that last for several days potentially affecting human health, will become more frequent and longer lasting as our climate warms [32]. Extreme heat is the leading cause of weather-related deaths and leads to extra emergency room visits and hospitalizations in people with chronic health conditions [33,34]. While extreme heat events affect people all over the world, some of the most dramatic recent heat waves have occurred in the mid-latitude climates affecting wealthier European countries and the United States; an extended heat wave in Europe in 2003 resulted in an

estimated 70,000 additional deaths across twelve countries [29]. Urban centers trap heat increasing the heat related risks in densely populated cities.

Heat cramps, heat exhaustion and heat stroke are risks for all people experiencing an extreme heat event, but some people are more vulnerable than others [35]. Young children, athletes, people with occupations that require them to be outside doing manual labor, people over 65, people with disabilities or chronic health conditions including mental illness or cognitive impairment, those living in poverty or social isolation, are less able to take protective measures to prevent heat-related conditions and dehydration [32].

Mental Health Risks Associated With Climate Change

Extremes related to climate change, such as extended heat events, flooding, droughts, or hurricanes / typhoons, expose all individuals to varying degrees of acute or traumatic events and community disruption in services. The degree of exposure to the extreme weather event generally determines the risk and level of psychological stress, although an individual's biological, social and economic factors also determine their risk [36]. Injury, illness, bereavement, loss of one's home and community, all contribute to the mental health stress associated with disastrous weather events [36]. Research evaluating mental health in people in the New Orleans metropolitan area post-hurricane Katrina, determined a high percentage of residents experienced anxiety-mood disorders and posttraumatic stress disorder [37]. These disorders were strongly related to experiencing physical illness or injury and property loss during the hurricane.

Many individuals experience some level of mental illness or emotional stress but are able to cope when their physical health and contextual environment are stable and they have access to regular mental health services [2]. Individuals with chronic mental health disorders comprise a vulnerable population more prone to posttraumatic psychopathologies after weather related disasters. Mental health services are often disrupted for prolonged periods of time after disasters, further affecting the health and recovery of affected individuals and communities.

Global Geopolitical Risks to Health Associated With Climate Change

The accelerated rate of climate change poses a severe risk to global political stability [1]. Food and water scarcity in the Middle East and Africa are leading to increased tensions in longstanding regional and ethnic rivals. As the world's population continues to grow and the impact of climate change on available food, water, and energy resources goes unabated, the distribution of these finite resources will have increasing security implications. Political power struggles for control of these resources are a likely scenario. Political instability and social unrest can lead to acts of terrorism and violence [1].

Rising sea levels in poor, densely populated areas of India, Bangladesh, and the Mekong Delta, could lead to new waves of refugees stressing neighboring countries and affecting health in these vulnerable populations [1]. As the Arctic icecap melts, struggles between countries over shipping access, fishing rights and resource exploration and use are anticipated [1]. Rising sea levels in the United States jeopardize key military facilities located along the coast. Much of the United States' energy infrastructure, refineries, power plants, electrical transmission lines, oil import terminals, are in coast areas

that could be affected by extreme weather events, rising sea levels and tidal surges .

The CNA Corporation Military Advisory Board (2014) strongly recommends that the United States assume a global leadership role in abating climate change where possible and prepare for the projected impacts of climate change. The report concludes that the projected impacts of climate change must be integrated into national planning for security, disaster management, infrastructure stability, food, water, and energy resources.

The United States is a developed country with available resources to modify some of the anticipated impacts of climate change. But even the United States cannot prevent extreme weather events, such as Hurricane Katrina, and the devastation to population health and the environment. Many developing countries do not have expendable resources to plan for future impacts of climate change, and therefore, are more vulnerable to the health consequences associated with climate change. These countries are also not the largest producers of heat-trapping gases, yet they will incur the greatest consequence.

The Role of Advanced Practice Nurses

There is a strong scientific consensus that global climate is changing and that this has implications for human health [2,19]. Much additional research is needed to further elucidate the health consequences of our changing climate [38]. Advanced practice nurses must be aware of the health consequences of climate change to provide care to their clients, educate the community regarding health risks regarding climate change, and lobby for public health planning to address the anticipated health consequences of climate change and measures to slow the global creation of greenhouse gases.

Increased air pollution poses health risks to all people, but individuals with respiratory conditions, such as asthma and chronic obstructive pulmonary disease, cardiovascular compromise, the elderly, and the very young, have increased risks associated with air pollution. Our clients with these increased risks should be counselled on the hazards of air pollution and encouraged to reduce activity and remain inside, preferable in air-conditioned facilities, during high air pollution days. They should be taught how to use governmental air quality index ratings to guide their daily activity. Individuals with complex and unstable respiratory or cardiac conditions should be identified and a system established of contacting them during high-risk air quality days to determine their health needs and remind them of their health care plan for high-risk days. A public health system of care is required to offer shelter and additional health care to those individuals living on the margins of society - the poor, isolated, immigrant, cognitively or mentally incapacitated.

Extreme weather events fortunately do not happen often but may increase with climate change. Weather forecasting has provided some ability to plan for extreme weather events but often the area affected and the devastation can be so great that health care services can be disrupted for prolonged periods of time. It is important for advanced practice nurses to educate their clients, especially those with chronic health conditions, on planning for disasters and the possible disruption of health care services. Disaster planning information and guidelines are available on government web sites and can be shared with clients and their families. It is important that patients have adequate supplies of their medications to manage their chronic health conditions for a period of one to two weeks and know how to use them appropriately if symptoms increase. Local emergency responders

should have a list of people with complex health conditions so in the case of emergencies they can be targeted for emergency services.

Extreme heat events require the same type of identification of clients at increased risk, education regarding the health hazards of heat and dehydration, and management of chronic health conditions that are complicated by the stresses of excess heat. Extreme heat events require a concerted public health response to offer cooling stations and health care for all people who need these services and public health announcements warning of the serious consequences of excess heat exposure. Ongoing climate change assures continued and increasing episodes of extreme heat events. These can and should be planned for and anticipated. This planning should include establishment of auxiliary health facilities for cooling and hydration services because past experience indicates emergency rooms and hospital facilities will be swamped with providing services and cannot be expected to manage the additional morbidity from an extreme heat event [39]. Advanced practice nurses can be part of this community planning process and may also be called upon to staff or administer the auxiliary health facilities.

As climate changes alters the regions infested by certain types of mosquitos and ticks, advanced practice nurses will need to expand their knowledge regarding vector-borne conditions, the symptoms, diagnosis, and treatment. Obtaining a travel history on people being seen for fever, rash, or other unidentified symptoms is always important. The Center for Disease Control and Prevention publishes biennially the CDC Health Information for International Travel [27], an excellent guide for identifying and treating possible vector-borne conditions or conditions caused by water contamination.

Advanced practice nurses must also become involved in the public planning for mitigation of climate change. Nurses should add their voices, as respected professionals, to the public and political discourse on climate change. The IPCC (2014) clearly outlines the impacts, vulnerability and adaptations needed to address climate change. This is not just a political issue. It is a health issue, and as advanced practices nurses we need to be actively involved in promoting the public health benefits of controlling greenhouse gases and planning for the health consequences of climate change [40-44].

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