JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

RESEARCH NEEDS TO MITIGATE THE IMPACT OF CLIMATE CHANGE ON HUMAN HEALTH

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ABSTRACT

This paper deals with research needs to mitigate the impact of climate change on human health. It outlines the research needs to mitigate the spread of asthma, respiratory allergies and air prone diseases consequent upon climate change, mitigation measures on cancer occurrence, cardio vascular disease, occurrence and food prone disease consequent upon climate change. This paper concludes with some interesting findings.

Keywords: Climate Change, Human Health, Preventive Measures

Introduction

Many potential direct effects of climate change on cancer risk, such as increased duration and intensity of ultraviolet (UV) radiation, are well understood; however the potential impact of changes in climate on exposure pathways for chemicals and toxins requires further study. Science should investigate the effects of mitigation and adaptation measures on cancer incidence so that the best strategies can be developed and implemented; for example, research to inform understanding of the benefits of alternative fuels, new battery and voltaic cells, and other technologies, as well as any potential adverse risks from exposure to their components and wastes. Better understanding of climate change impacts on the capacity of ocean and coastal systems to provide cancer curative agents and other health-enhancing products is also needed.

Climate change may exacerbate existing cardiovascular disease by increasing heat stress, increasing the body burden of airborne particulates, and changing the distribution of zoometric vectors that cause infectious diseases linked with cardiovascular disease. Science that addresses the cardiovascular effects of higher temperatures, heat waves, extreme weather, and changes in air quality on health is needed, and this new information should be applied to development of health risk assessment models, early warning systems, health communication strategies targeting vulnerable populations, land use decisions, and strategies to meet air quality goals related to climate change. In some areas, cardiovascular and stroke risks resulting from climate change could be offset by reductions in air pollution due to climate change mitigation.

Climate change may be associated with staple food shortages, malnutrition, and food contamination of seafood from chemical contaminants, biotoxins, and pathogenic microbes, and of crops by pesticides. Science research needs in this area include better understanding of how changes in agriculture and fisheries may affect food availability and nutrition, better monitoring for disease-causing agents, and identification and mapping of complex food webs and sentinel species that may be vulnerable to climate change. This research could be used to prepare the public health and health care sectors for new illnesses, changing surveillance needs, and increased incidence of disease, as well as development of more effective outreach to affected communities.

Heat-related illness and deaths are likely to increase in response to climate change but aggressive public health interventions such as heat wave response plans and health alert warning systems can minimize morbidity and mortality. Additional science should be focused on developing and expanding these tools in different geographic regions, specifically by defining environmental risk factors, identifying vulnerable populations, and developing effective risk communication and prevention strategies.

Two potential consequences of climate change would affect normal human development: malnutrition—particularly during the prenatal period and early childhood as a result of decreased food supplies, and exposure to toxic contaminants and biotoxins—resulting from extreme weather events, increased pesticide use for food production, and increases in harmful algal blooms in recreational areas. Research should examine the relationship between human development and adaptations to climate change, such as agriculture and fisheries changes that may affect food availability, increased pesticide use to control for expanding disease vector ranges, and prevention of leaching from toxic waste sites into floodwaters during extreme weather events, so that developmental consequences can be prevented.

By causing or contributing to extreme weather events, climate change may result in geographic displacement of populations, damage to property, loss of loved ones, and chronic stress, all of which can negatively affect mental health. Research needs include identifying key mental health effects and vulnerable populations, and developing migration monitoring networks to help ensure the availability of appropriate health care support.

Climate change, as well as attempts to mitigate and adapt to it, may increase the number of neurological diseases and disorders in humans. Research in this area should focus on identifying vulnerable populations and understanding the mechanisms and effects of human exposure to neurological hazards such as biotoxins (from harmful algal blooms), metals (found in new battery technologies and compact fluorescent lights), and pesticides (used in response to changes in agriculture), as well as the potentially exacerbating effects of malnutrition and stress.

Disease risk may increase as a result of climate change due to related expansions in vector ranges, shortening of pathogen incubation periods, and disruption and relocation of large human populations. Research should enhance the existing pathogen/vector control infrastructure including vector and host identification; integrate human with terrestrial and aquatic animal health surveillance systems; incorporate ecological studies to provide better predictive models; and improve risk communication and prevention strategies.

Increases in water temperature, precipitation frequency and severity, evaporation-transpiration rates, and changes in coastal ecosystem health could increase the incidence of water contamination with harmful pathogens and chemicals, resulting in increased human exposure. Research should focus on understanding where changes in water flow will occur,

how water will interact with sewage in surface and underground water supplies as well as drinking water distribution systems, what food sources may become contaminated, and how to better predict and prevent human exposure to waterborne and ocean-related pathogens and biotoxins.

Increases in the incidence and intensity of extreme weather events such as hurricanes, floods, droughts, and wildfires may adversely affect people's health immediately during the event or later following the event. Research aimed at improving the capabilities of healthcare and emergency services to address disaster planning and management is needed to ensure that risks are understood and that optimal strategies are identified, communicated, and implemented.

Mitigation and Adaptation

Mitigation and adaptation strategies have the potential to both positively and negatively affect human health.

Alleviate some of the health effects associated with exposure to chronic or acute heat, but also can potentially result in higher greenhouse gas emissions and further declines in air quality, depending on the method of power generation. Health-based research to inform the use of novel fuel mixtures and electric vehicles will be important. Some impacts have been well characterized through life-cycle analyses, while others, particularly those related to novel fuels and energy sources, and have yet to be assessed. Careful analyses of mitigation and adaptation co-benefits and tradeoffs are necessary so that appropriate strategies are adopted.

Research Needs to Mitigate the Air Prone Diseases

Climate change will likely amplify existing environmental stimulation of asthma, respiratory allergies, and airway disease, resulting in more severe and frequent disease exacerbations and an increase in the overall burden of these conditions. Thus, continued research on climate change's effect on alterations in the composition of aeroallergens and air pollutant mixtures and their consequent effects on health is essential. Research needs include: developing and validating real-time remote sensing and other *in situ* monitoring techniques to evaluate air quality, aeroallergens, aerosolized pathogens, dust burdens, and other climate-sensitive exposures directly linked to asthma and airway diseases, understanding and modeling the impact of climate change on air quality, aeroallergens, and aerosolized marine toxins, and the resulting effects on asthma and airway diseases including in vulnerable populations, applying modeling originally developed to assess health effects of air pollution and other ecological niche modeling to climate-sensitive diseases, establishing climate-sensitive exposure metrics, with appropriate temporal and spatial dimensions, that are most strongly associated with asthma, allergy, and airway diseases, identifying and mapping populations and communities at increased risk of climate-related respiratory disease, which will also help to identify populations at risk for other climate-related health impacts as many environmentally mediated diseases share common risk factors, using epidemiological investigations to study the relationship between climate variables; altered production, distribution, and reactivity of pollen and marine toxins; changes in air pollutants; and the prevalence, severity, and onset of asthma exacerbations, studying the health effects of airborne and indoor dust on asthma exacerbation, including changes in dust composition resulting from climate change, understanding the acute and long-term impacts of wildfires on asthma and other respiratory diseases, examining chemicals used in energy efficient technologies to ensure that they do not contribute to lung sensitization, asthma, or

other respiratory diseases, examining the relative risks for respiratory disease based on chemicals with lower global warming potential than existing greenhouse gases, developing early warning systems for state and local governments and public and environmental health officials to anticipate and mitigate climate-related health impacts, improving methods of identifying risks and communicating with vulnerable populations to reduce climate change impacts on all respiratory diseases and developing decision support tools including health impact assessments (HIAs) of the burden of respiratory diseases attributable to climate change for help in identifying and selecting climate change and air quality mitigation and adaptation policies that will promote health benefits.

Research needs also call for improvements in various capacities and skills. Air pollution modeling is well established and the health impacts of several species of particles and aeroallergens are reasonably well understood. However, the complex introduction of aeroallergens under a changing climate will require the expansion of scientific expertise to include botany and ecology in addition to meteorology and the built environment. Research will require the use of geographic information systems and remote sensing expertise in new ways, as well as the application of novel vulnerability mapping techniques, early warning systems, and other public health tools. Spatial epidemiological methods will bring new power to ecological studies of air quality and public health. Identification and collection of integrated and appropriately scaled social, ecological, and epidemiological data are needed for effective monitoring and modeling. For health communications, novel strategies are required to identify vulnerable populations and develop communication strategies that will effectively reduce risk.

Mitigation and Adaptation on Climate Change Induces Cancer Incidence

In addition to direct impacts of climate change on cancer, the impact of mitigation strategies on cancer should also be considered. For instance, co-benefits of decreased greenhouse gas emissions and decreased cancer incidence may be attainable with energy efficient power generation and reduced emissions through lower vehicle miles traveled. These benefits could be realized through decreases in toxic outputs of fossil fuel-based power generation and transportation, including sulfur oxide and particulate matter (PM), which have been implicated in lung cancer.

Decreases in greenhouse gas emissions are generally associated with decreases in cancers that occur due exposure to such pollutants. Increased energy efficiency will lead to reductions in emissions of sulfur dioxide, nitrous oxides, and particulate matter, which should lead to reductions in rates of premature death including from certain cancers. In most cases, these emission reductions will also result in subsequent reductions in ambient concentrations of ozone and secondary particulate matter 2.5, which have been implicated in a variety of health effects including lung cancer. Reductions in other hazardous air pollutants, such as heavy metals from power generation and industrial processes that are known or suspected to cause cancer or other serious health effects, may also occur.

Several technologies currently being pursued to decrease greenhouse gas emissions may also help to reduce cancer incidence. For example, reducing greenhouse gas emissions from the transportation sector may be accomplished by reducing vehicle miles traveled through a variety of approaches such as high-density development, preservation of green space, and widespread use of mass transit. However, the impacts of some mitigation technologies on cancer have not been fully explored.

For example, nanotechnology may be promising for mitigating climate change through its use in efficient hydrogen powered vehicles, enhanced and cheaper solar power technology, and

the development of a new generation of batteries and super capacitors, yet little is known about potential links to cancer and other health outcomes.

New technologies have been proposed to decrease our dependence on greenhouse gas-intensive power generation and fuel use. However, many of these have potential impacts on cancer that should be more fully investigated prior to being implemented. The widespread adoption of biofuels may have unintended consequences including possible increases or decreases in cancer due to a change in the level of existing pollutants or the creation and emissions of new air pollutants. Also, barring changes in agricultural practices, there is potential for increased pesticide use for the growth of certain biofuels such as corn ethanol. Exposure to some legacy pesticides has been implicated for cancer in both adults and children, leading to current efforts by the EPA to avoid this problem in new products.

Research is needed to understand if there are cancer implications from the use of electric vehicles, including the production and disposal of portable electric storage systems. Manufacturing of batteries for electric cars and photovoltaic (solar) power systems may have consequences including increased exposure to metals. The most common type of battery currently in use is the nickel-metal-hydride (NiMH) battery, with other types of batteries (lithium ion, lithium ion polymer, valve regulated lead acid, and nickel-cadmium) also under development for vehicle use. Increased use of NiMH batteries will necessarily require significant increases in nickel production and the impacts associated with nickel mining and refining. High-level nickel exposure is associated with increased cancer risk, respiratory disease, and birth defects; the same is true with certain other metals, especially cadmium and lead.

Research Needs in the Context of Climate Change Impact on Cancer

Many of the cancer risks resulting from the direct effects of climate change have been fairly well studied. The largest research gaps are in the materials and methods used for mitigation and adaptation, and their potential to increase or decrease cancer risks. Research needs include:

• utilizing animal cancer surveillance and investigations as sentinel biomedical models to better understand the environmental factors, mechanisms, and pathways of mammalian cancer risk.
• developing and sustaining facilities and expertise to rapidly assess and monitor the threat of previously unrecognized toxins, carcinogens, and other bioactive molecules produced in response to stress on marine environments.
• understanding the impact of increased heavy precipitation and flooding events on the risk of toxic contamination of the environment from storage facilities or runoff from land containing toxic chemicals, including the geographical areas, ecosystems, and populations most likely to be impacted and the health outcomes that could result.
• understanding how climate changes such as changes in temperature and precipitation affect exposure to toxic chemicals including volatile and semi-volatile compounds and known or suspected human carcinogens.
• elucidating the effects of ambient temperature on UV radiation-induced skin cancers, including the amplification of non-melanoma skin cancers.
• evaluating the potential cancer risks through the entire life cycle of biofuel production, including risks from novel air pollutants and changes in agricultural practices that may increase exposures to pesticides, herbicides, and other environmental contaminants.
• understanding cancer risks from the life cycle emissions of carcinogens and untested compounds associated with alternative energy and transportation technologies, particularly electricity storage systems and photovoltaic systems.

• clarifying the life cycle cancer risks of nuclear energy radiation, including through occupational and environmental exposures.
• developing mechanisms to conserve and explore marine and terrestrial biodiversity in environments likely to yield cancer cures and treatments.
• characterizing and quantifying changes in cancer rates from implementation of specific greenhouse gas mitigation strategies, especially for existing fossil fuel-based energy production and use.

Mitigation and Adaptation of Climate Change Induced Cardio vascular Diseases

The likely impacts of climate change mitigation activities on risk of cardiovascular disease and stroke depend primarily on emissions-associated energy production activities, particularly in the transportation sector. Some mitigation activities related to energy production, such as the increased use of wind, wave, solar, and nuclear sources of power generation, are likely to reduce cardiovascular disease risks by reducing particulate and other air pollution emissions.

Mitigation activities such as increasing the density of urban development, enhancing public transportation options, and encouraging alternatives to single occupancy vehicle use are likely to benefit cardiovascular fitness, reducing the overall burden of cardiovascular disease. More research is needed, including economic analyses, to determine the most beneficial strategies to pursue. As with reparatory health risks, risks of cardiovascular disease and stroke may be reduced in urban populations through filtration of ambient pollutants by tree cover. Co-benefits of tree cover include heat-island alleviation, reduced energy use to cool buildings, and consequent reductions in greenhouse gas emissions.

Fuel mixtures each have different particulate and other criteria pollutant profiles, and variously reduce net greenhouse gas emissions. Fuel mixtures associated with high emissions of particulates or other pollutants such as nitrous oxides and carbon monoxide will have adverse impacts on cardiovascular health, as these pollutants are associated with incidence of cardiovascular hospital admissions among those with existing heart disease. Preliminary analysis of certain biodiesel blends is promising but more research is needed to fully characterize likely health impacts of large-scale mitigation activities related to transport fuels. Some biodiesel blends appear to produce emissions with few negative health consequences. While an association between PM exposure and increased risk of cardiovascular disease has been demonstrated, it is unclear which chemical constituents mediate this effect.

More research is needed to better identify these pollutants, which in turn will help to predict the potential benefits of alternative combustible fuels. Due to unique electrophysiological properties associated with the very high heart rates of the rodents most commonly used in researching dysrhythmia, these biomedical models do not always closely replicate human conditions. In contrast, the rates and underlying physiology of fish hearts are closer to humans and, as such, fish models should be explored as tools for understanding and screening the effects of various transport fuels.

Projecting the health impacts of adaptation activities, particularly the increased use of air conditioning to protect vulnerable populations from extreme heat, requires assumptions regarding how these activities will be powered. For instance, if significant additional electricity demand is met through increased fossil fuel combustion, then there is likely to be increased exposure to particulates and ozone as a result. However, these exposures may be partially offset by the protective effect of air conditioning. Most other adaptation activities are likely to have little direct impact on cardiovascular disease incidence.

Research Needs to Reduce the Incidence of Cardio Vascular Diseases

As noted, there are significant gaps in our understanding of climate change impacts on cardiovascular disease, particularly for morbidity, and there is virtually no research projecting future cardiovascular health impacts of climate change. Research needs include:

• increasing research on the incidence of cardiac dysrhythmia and associations with temperature and other environmental exposures.
• enhancing research on the complex synergistic effect of temperature, weather variability, long-term climate change, and environmental exposures such as criteria air pollutants on the incidence of various cardiovascular disease outcomes.
• intensifying investigation of the likely cardiovascular complications.
• characterizing the multiple individual constituents of air pollution to better anticipate the health effects from switching the mix of pollutants in air through the use of alternative fuels.
• studying strategies for incorporating cardiovascular disease outcomes in HIAs and integrated assessment climate models, including further characterization of exposure-outcome associations for cardiovascular morbidity in different geographic regions developing a national standard for heat-related mortality to facilitate epidemiologic study of mortality from heat and other co-morbid conditions targeting research on early warning systems and health communications aimed at groups particularly at risk for adverse cardiovascular outcomes related to climate change identifying and quantifying the co-benefits to cardiovascular health of reducing our reliance on fossil fuel-based energy and changing emission scenarios. Characterizing both the potential health risks and benefits of novel fuels and other energy production activities being considered for large-scale adoption as part of a national mitigation strategy.

Several cardiovascular disease research priorities dovetail with other areas. In particular, research into health impacts of increased temperature, extreme weather, and changes in air quality associated with climate change will inform research into cardiovascular health impacts. Similarly, research into early warning systems and integrated assessment models is transferable to other health outcomes associated with climate change, and research into the health impacts of potential mitigation and adaptation activities can be applied to other health outcomes sensitive to particulate and other emissions.

Mitigation and Adaptation on Food and Nutrition

In the long term, mitigation and adaptation decisions affecting food and nutrition including, for example, the diversion of staple crops for befoul feedstock, the increased need for agricultural chemicals due to climate-related increases in pests and changes in pest habitats, and planning needs for the maintenance of food supply infrastructure and transport in the wake of extreme weather events are important factors to be considered in a strategic research plan for climate change and health. The benefits of befouls, genetically modified organisms, new pesticides, and alternative energy on nutrition and food borne illness must also be considered. All of these technologies have great potential to help humans mitigate and adapt to climate change, and each should be carefully evaluated to ensure that the best are implemented.

Health implications, both positive and negative, of changes in animal agriculture and aquaculture as a result of climate change mitigation and adaptation need to be identified and quantified. For example, climate change events such as drought and flooding can result in changes in animal feed quality and the use of marginal lands for animal grazing affects water and habitat quality. Better understanding is needed of effects of the use of new or increased

herbicides and pesticides in response to changes in growing conditions caused by climate change, as well as potential health effects for both humans and animals of ingestion of crops that have been genetically modified to withstand stress conditions caused by climate change. The health implications of biomass-based energy and befouls, including interactions between climate mitigation strategies affecting agricultural and energy policies and availability of food, must be a priority area of research.

Research Needs on Food and Nutrition in the Context of Climate Change

New efforts are needed to combine current and anticipated advances in detection and warning systems for food, nutrition, and food borne health threats with epidemiologic studies on the occurrence and severity of poor nutrition and food borne disease in humans. This is especially needed for high-risk populations such as women, infants, and children, and people in resource-constrained settings. Research needs include:

• projecting impacts of climate change including increases in CO2, temperature, drought, floods, and other extreme weather events, and changes in growing seasons on food production, availability, contamination, and nutritional value
• understanding and predicting potential ecosystem changes from climate change that may establish new food borne pathogens, chemical contaminants, or biotoxins, as well as new pathways for human exposure
• assessing the impacts of climate change on outbreak incidence, geographic range, and growth cycles of insect pests and pathogens that can infect food crops and seafood, and cause human disease
• understanding the effects of changes in food safety due to climate change-related alterations in the accumulation and toxicity of food borne contaminants, biotoxins, and pathogens
•understanding of changes in nutritional status associated with climate change that may increase individual susceptibility to the adverse health impacts of other environmental exposures such as chemicals and heavy metals
•improving surveillance of disease-causing agents (chemical contaminants, pathogens, toxins) in food animals, agricultural crops, and seafood, as well as monitoring of exposed human populations in order to improve estimates of disease related to contamination of the food supply
• identifying and characterizing aspects of food production and distribution systems that will reduce risk of contamination and disease and ensure sustainability under climate change scenarios
• understanding the effect of ocean acidification from climate change-related increases in air pollution on seafood quality and availability
• developing and implementing models linking climate change and other environmental data (such as land use, land cover, hydrology) to crops and seafood to improve prediction and risk assessment
• developing and implementing early warning systems to manage agriculture and fisheries risks related to climate change, including improved communications with domestic and international food security agencies

Conclusion

It could be seen clearly from the above discussion that research needs are very essential to develop mitigation and adaptation options in the context of climate change impact on human health. The identification of research needs to mitigate the asthma; allergies and air way diseases, cancer and cardio vascular diseases are discussed in this paper. Such type of

discussion enables the planners and health policy makers to develop appropriate mitigation measures to overcome the negative impact of climate change on human health.

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