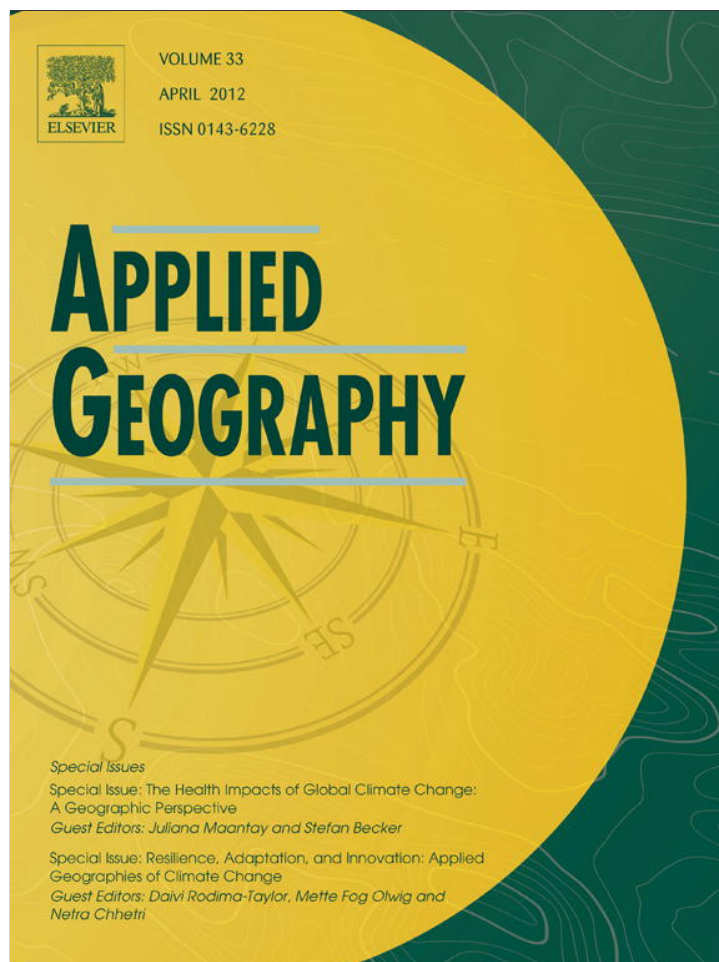


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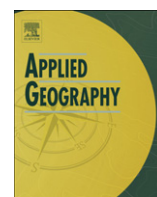


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## The health impacts of global climate change: A geographic perspective

An often-overlooked consequence of global climate change is the potentially severe impacts to public health. Throughout the world, the local climate and weather events strongly influence the prevalence of some diseases and other threats to human health (EPA, 2011). Direct and indirect impacts of climate change have considerable potential to cause significant loss of life, affect communities, and increase health-care costs and lost work days (IPCC, 2007). Given the complexity of factors that influence human health, assessing health impacts related to climate change often poses a difficult challenge.

Effects of climate change on human health can be categorized into direct and indirect temperature effects, effects of extreme events such as storms, floods, and droughts, effects of the spread of climate-sensitive diseases, effects of air quality, and other effects on human health.

### Direct and indirect temperature effects

Direct effects of increasing temperatures are often related to the fact that an increase in average temperatures in a specific region is generally associated with an increased probability of extreme events such as heat waves. Particular segments of the population such as those with heart problems, asthma, the elderly, the very young and the homeless and displaced persons can be especially vulnerable to extreme heat (EPA 2011). The National Weather Service statistical data shows that heat causes more fatalities in the U.S. per year than floods, lightning, tornadoes and hurricanes combined. Heat stress is associated with heat edema (swelling of the extremities), heat rashes (skin irritation), heat fatigue (from fluid loss), heat syncope (sudden dizziness or fainting, blood pooling in lower extremities leading to insufficient flow of blood to the brain), heat cramps (muscle spasms in the abdomen, arms, or legs), heat exhaustion (response to an excessive loss of water and salt, dehydration), or heat stroke and hyperpyrexia (elevated body temperature, failure of the body's temperature regulation mechanism). Indirect heat-related health effects include reduced work performance, increased accidents, reproductive problems, heart or lung strain, and increased mortality rates.

### Effects of extreme events such as storms, floods, and droughts

Changes in temperature, air pressure, and precipitation patterns affect the probability of storms and floods. Higher tropical air and water temperatures are likely to be associated with an increase of intense tropical cyclone activity; however, given the complex nature of tropical cyclones, the existence of a direct connection between climate change and tropical cyclone activity is still

discussed controversially among scientists. Numerous studies have linked climate change to changes in storm activity and extreme rainfall events worldwide. The early health effects of floods resulting from extreme rainfall include death through drowning and accidents such as falls, electrocution, and the effect of landslides. In addition, floods were linked to various other short- and long-term impacts on physical and psychosocial health such as injuries (as individuals attempt to remove themselves, their family, or valued possessions from danger), various diseases (discussed below), and mental health (anxiety, depression, posttraumatic stress syndrome, and suicide) (Ahern, Kovats, Wilkinson, Few, & Matthies, 2005). Changing precipitation patterns leading to droughts often create a lack of clean water for drinking, public sanitation and personal hygiene, which can lead to a wide range of life-threatening diseases. In addition, droughts can create hazardous conditions in forests and across range lands, setting the stage for wildfires that may cause injuries or deaths as well as extensive damage to already shrinking food supplies. Droughts (and resulting wildfires) are also associated with increased wind erosion which affects human health through increased levels of particulate air pollution.

### Effects of the spread of climate-sensitive diseases

Climate change may increase the risk of some infectious diseases, particularly those diseases that appear in warm areas and are spread by mosquitoes and other insects. These “vector-borne” diseases include malaria, dengue fever, yellow fever, West Nile virus, and encephalitis (EPA 2011). Many serious diseases are transmitted by mosquitoes, which breed in, or close to, stagnant or slow-moving water. Warming and increased rainfall contribute to stagnant or slow-moving water and with this to the abundance and distribution of mosquitoes and ticks (Zhou, Minakawa, Githeko, & Yan, 2004). Increased global temperatures allow mosquitoes to survive winters where they would otherwise have perished (Hales, de Wet, Maindonald, & Woodward, 2002). Subsequently, more mosquitoes are alive to breed and transmit disease during the summer season. In addition, mosquito larvae develop much faster at higher temperatures and after ingestion of the virus become more infectious at higher temperatures (Patz, Martens, Focks, & Jetten, 1998). Local floods resulting from extreme rainfall events can contribute to the spread of rodent-borne diseases (such as hantavirus pulmonary syndrome -HPS or lymphocytic choriomeningitis - LCMV, or leptospirosis) or fecal-oral diseases (especially in areas where the population does not have access to clean water and sanitation).

### Effects of air quality

Climate change is expected to contribute to some air quality problems (IPCC, 2007). Respiratory disorders may be exacerbated by warming-induced increases in the frequency of smog (ground-level ozone) events and particulate air pollution (EPA 2011). Long latency times, the effects of cumulative exposures, and multiple exposures to different pollutants which might act synergistically all create difficulties in unraveling associations between environmental pollution and health.

Ground-level ozone is not emitted directly into the air, but forms through a reaction of nitrogen oxides (NO<sub>x</sub>), volatile organic compounds (VOCs), carbon monoxide (CO) and methane (CH<sub>4</sub>) in the presence of sunlight. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are the major man-made sources of NO<sub>x</sub> and VOCs. The link to climate change stems from the fact that sunlight and hot weather accelerate the formation of ozone. The negative effects of ozone on humans have been widely discussed. Breathing air containing ozone can reduce lung function and increase respiratory symptoms, thereby aggravating asthma or other respiratory conditions. Ozone exposure also has been associated with increased susceptibility to respiratory infections, medication use by asthmatics, doctor visits, and emergency department visits and hospital admissions for individuals with respiratory disease. Ozone exposure may also contribute to premature death, especially in people with heart and lung disease (<http://www.epa.gov>).

The link between climate change, droughts, and increased levels of particulate air pollution has been explained above. Particles can affect the heart and lungs and cause serious health effects. Numerous studies link particulate matter to lung cancer and cardiopulmonary diseases and mortality.

Though a great deal of uncertainty remains regarding the expected future impacts of climate change on air quality, recent research suggests that such effects may be very significant, particularly on a local or regional scale.

### Other effects of climate change on human health

Many other, less direct linkages are proven or expected to exist between climate change and human health. For example, regional climate change impacts on agricultural yields and production are likely to grow over time, with the most negative effects expected in developing countries. This is expected to increase the number of undernourished people globally and consequently lead to complications in child development (IPCC, 2007). Changes in agricultural production, water availability, and extreme weather events are expected to cause social disruption and displacement of populations in certain regions that could result in a myriad of health issues. As another example, salt water intrusion into groundwater as a consequence of sea level rise is expected to cause a lack of fresh water in some regions which again would be associated with numerous health implications.

### Uneven distribution of impacts: environmental health justice implications

*“The extent and nature of climate change impacts on human health vary by region, by relative vulnerability of population groups, by the extent and duration of exposure to climate change itself and by society’s ability to adapt to or cope with the change,” (EPA 2011).*

Although the health impacts of climate change are global in scale, they are not distributed evenly throughout the world, but

will tend to have the greatest negative ramifications for those populations who are already most at risk for adverse health outcomes, high infant mortality, and lower life expectancies. These populations include the poor in many countries, those living in less affluent countries, and children and the elderly. In this way, the health impacts of global climate change must be considered an environmental justice issue, as well as a health equity issue. The spatial variability of the various health issues that are proven or expected to be associated with our changing climate makes this subject truly “geographic” in nature.

### The health impacts of global climate change: a geographic perspective

This special issue of *Applied Geography*, “The Health Impacts of Global Climate Change: A Geographic Perspective,” aims to bring a cross-section of these ideas to the forefront. Through the use of case studies of specific locations around the world, the new research featured in this issue demonstrates a cutting-edge view of many of the pressing problems and their likely extent.

A comprehensive meta-analysis was conducted to identify and evaluate the existing body of literature concerning the potential public health impacts of climate change (Maantay and Gangadeen, in preparation). The databases searched were Pubmed, Springerlink, and Google Scholar, with key words such as climate change, human health, and public health, resulting in approximately 1900 references, of which 146 papers were assessed in the meta-analysis. Papers were selected and assessed based on several factors, including area of study (identifying the location and size of study area, regional or global); research focus (human health impact associated with specific climate change events); and the paper’s publication date (2000 to present). The findings indicate that the majority of published literature provides a broad outlook regarding climate change and public health impact. Over 60% of the papers reviewed were on a global scale focusing on the overall health impacts based on climate variability - for example vector-borne diseases, water-borne diseases, heat stress, etc. The remaining literature focused on regional areas such as Europe, Africa, or the USA, looking at the overall health impact due to various diseases, with a substantial proportion of the regional studies focused on Malaria and Dengue Fever in Africa.

Our findings indicate that there is a lack of regional research focusing on specific local anthropogenic factors and how they contribute to human health impacts due to events connected with global climate change. Based on these findings of the meta-analysis, we determined that this constituted a serious gap in the literature, which this collection of 10 research papers will begin to address.

- *Climate Change and Human Health: Spatial Modeling of Water Availability, Malnutrition, and Livelihoods in Mali, Africa* (Jankowska, Lopez-Carr, Funk, Husak, and Chafe)
- *Climate Change and Health and Social Care: Defining Future Hazard, Vulnerability and Risk for Infrastructure Systems Supporting Older People’s Health Care in England* (Oven, Curtis, Reaney, Riva, Ohlemuller, Dunn, Nodwell, Dominelli, and Holden)
- *Climate Change and Environmental Injustice in a Bi-National Context* (Grineski, Collins, Ford, Fitzgerald, Aldouri, Velázquez-Angulo, and Lu)
- *Climate Change-Related Vulnerabilities and Local Environmental Public Health Tracking through GEMSS: a web-based visualization tool* (Houghton, Prudent, Scott, Wade, and Lubner)
- *The Spatial Variability of Heat-Related Mortality in Massachusetts* (Hattis and Ogneva-Himmelberger)
- *Expanding geographical distribution of the mosquito, *Culex pipiens*, in Canada under climate change* (Hongoh, Ford, Scott, and Lindsay)

- *The impact of rainfall and temperature variation on the prevalence of diarrhea in Sub-Saharan Africa* (Bandyopadhyay, Kanji, and Wang)
- *Climate and Health in Florida: Changes in risks of annual maximum temperatures in the latter half of the Twentieth Century* (Waylen)
- *Empirical mapping of suitability to dengue fever in Mexico using species distribution modeling* (Machado)
- *GIS-based identification of spatial variables enhancing heat and poor air quality in urban areas* (Merbitz, Buttstädt, Michael, Schneider, and Dott)

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