Health Effects of Climate Change

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Abstract

Climate change and environmental degradation are closely interlinked and pose a formidable, although not insurmountable, challenge. The evidence of climate change and global warming is now incontrovertible, although amount, rate, and intensity of such change is still subject of debate. The potential health effects of climate change are immense. Climate change is no longer an environmental issue alone but is also a health issue of immense import and impact. It is now well recognized that a major, and perhaps the biggest, challenge affecting the success of policies aimed at mitigation is the life-style of those living a life of luxury and affluence in rich nations (and a miniscule minority in poor nations).

In the ultimate analysis, it will be the ability of health systems to respond efficiently and effectively to direct and indirect adverse health effects of climate change that will determine future health outcomes of the population. In addition to reorientation of health policy planning and reorganization of health systems, additional investments in appropriate technology and human resource development, are critical. At an individual level, a low-carbon living will not only enhance quality of life, but will also result in health and environmental benefits.

KeyWords: climate change, global warming, greenhouse gases, infection diseases, adaptation and mitigation, carbon footprint, public health system.

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Preamble

Whoever wishes to investigate medicine properly, should proceed thus: in the first place to consider the seasons of the year, and what effects each of them produces for they are not at all alike, but differ much from themselves in regard to their changes. Then the winds, the hot and the cold, especially such as are common to all countries, and then such as are peculiar to each locality. In the same manner, when one comes into a city to which he is a stranger, he ought to consider its situation, how it lies as to the winds and the rising of the sun; for its influence is not the same whether it lies to the north or the south, to the rising or to the setting sun.-

Hippocrates ("Airs, waters, and places." ~ 350 BC)

The temperature of the Earth is determined by the balance between energy transmitted to earth through solar short-wave radiation (ultraviolet radiation plus that in visible spectrum), and energy loss as nearly one-third of this energy is reflected back into space. The remainder is absorbed by the land and oceans, which radiate such acquired warmth as long-wave 'infrared' radiation. Atmospheric gases such as carbon dioxide, ozone, methane, and nitrous oxide are known as Green House Gases (GHG) which absorb some of this long-wave radiation. This greenhouse effect is needed, as in its absence, the earth would be about 35°C colder. Since the ushering in of industrial revolution, fossil fuels such as oil, coal, gas have been burnt as sources of energy, thus increasing greenhouse effects and increasing the Earth's temperature. It is estimated that we burn 196,442 kg of coal, 103,881,279 litres of gas, and 150,179 litres of oil per second, releasing 40 billion tones of CO_2 annually into the atmosphere, half of which lies within three miles of earth's surface (1). The GHG has been further accentuated by extensive deforestation, irrigated agriculture, and animal husbandry. It is estimated that industrial activity has released approximately 900 billion

tonnes of CO_2 into the atmosphere; of this nearly half has stayed there. It was as early as 1896 that the Swedish scientist Svante Arrhenius suggested that human activity of the type mentioned above would add CO_2 to the atmosphere, thus warming the earth. His predictions were subsequently confirmed by Thomas Chamberlin (2).

Problem and Perspective

Global warming is the most vital concern confronting the existence of our planet. It is the biggest health threat of the 21st century. This may be considered an alarmist view but the evidence for an ongoing global warming, largely attributable to emissions of GHG, is undeniable. In 1997 and 1998 global temperatures reached their highest levels since the time that temperature records have been maintained. Nine of the eleven hottest years in the twentieth century occurred in the last decade of the century (3): 1998 was the warmest year (4). Of greater concern is the fact that further warming will continue to occur. Three studies indicating disproportionate mid-atmospheric warming (5), disproportionate night time and winter warming (6), and increased variability (7), have all resulted in a recent report by the Intergovernmental Panel on Climate Change (IPCC) which estimates current global warming to be approximately 0.8°C above pre-industrial revolution era, and on the basis of 23 atmosphere-ocean general circulation models has predicted future temperature rises on the basis of six emission scenarios. They forecast a further projected rise of 1.1–6.4ºC by 2100 AD (8). The IPCC, a major international scientific collaboration, was established in 1988 by the World Meteorological Organisation and the United Nations Environmental Programme. The IPCC has comprehensively reviewed the science of climate change and its potential impacts (9). The recognition accorded to IPCC through the award of Nobel Prize has reaffirmed its scientific credentials and international credibility. The impact of current global warming is quantifiable in terms of physical systems such as the rise of sea levels and melting and retreat of glaciers; the models predict an increase in global mean sea levels of 18-59 cm (4). In addition, alterations in rainfall patterns such as monsoons possibly due to exaggerated El Niño effect, along with several other tipping points may result in alterations in several biological systems. There is evidence that El Niño

events have increased in magnitude since the mid-1970s (10). Greater variability from norms may increase the potential of abrupt climate change. Unpredictable occurrence of extreme climate-events such as storms, floods, heat waves and droughts may lead to devastating impact on human society. Coastal cities and towns will be most vulnerable as sea level rise will potentiate the effects of floods and storm surges. Increased frequency and magnitude of extreme climate events, along with reduced water and food security will most adversely affect health of billions of people.

While the effects of climate change on the environment and on the flora and fauna have been well documented and such information has been widely disseminated, there has been a somewhat delayed response on the part of health professionals to respond to the challenge of global warming. It is estimated that climate change has been responsible for 5.5 million disability adjusted life years (DALYs) lost in 2000. Table 1 shows that Southeast Asia Region which includes India leads in terms of total DALYs lost. What is most striking is that the figure for SEA region is nearly 300-fold higher than that of the developed countries (11).

The damage done to environment by modern society has resulted in one of the most inequitable health risks. The

Table 1. Estimated Effects of Climate Change in 2000, by WHO Region

Region	Total DALYs (1000s)	*DALYs Per million population
Africa	1894	3071.5
Eastern Mediteranean region	768	1586.5
South America and Caribbean region	92	188.5
Southeast Asia region	2572	1703.5
Western Pacific region	169	111.4
Developed countries	8	8.9
World	5517	920.3

* Disability Adjusted Life Year

carbon footprint of the poorest one billion people is around 3% of the world's total contribution. Yet, the poorest in the South East Asia and Africa will have a loss of healthy life years about 300 times greater and 200 times greater, respectively as compared to DALYs lost in the developed countries. Nevertheless, it should not be of any satisfaction to the rich. "The rich will find their world to be more expensive, inconvenient, uncomfortable, disrupted and colourless; in general, more unpleasant and unpredictable, perhaps greatly so. The poor will die" (12).

At the World Health Assembly held in May 2008 at Geneva, 193 Members States directed the WHO to collate and consolidate evidence base regarding human health implications of climate change so as to facilitate informed debate, generate well formulated policy framework, evolve sound intervention strategies, and develop time bound action plans at the International, Regional, and Country levels (13). Responding urgently and positively to such expressed concerns, WHO convened a meeting of 80 international experts along with representatives of donor and other UN agencies, in Madrid, Spain from 6-8 October, 2008. There was an agreement on a research agenda to develop an evidence-based framework for action on the human health implications of climate change.

"Many agencies, including WHO, have highlighted the health dangers of climate change" said Dr. Margaret Chan, WHO's Director-General. "Our 193 Member States asked WHO to help them strengthen the evidence base for policy action. This plan provides the framework for doing just that. It sets out guidance to governments, research institutions and donors looking to fill crucial knowledge gaps". The research plan identifies five priority research areas (14). Let me designate it as WHO ***Panchsheel*** as it provides parameters for a healthful co-existence between man and his environment. The ***Panchsheel*** includes:

- *Interactions with other health determinants and trends*: Climate change does not act in a vacuum. A comprehensive understanding of the issues involved must be based on interactions with important health determinants and trends such as economic development, globalization, urbanization, and inequities both in terms of exposure to health risks and access to care.

- *Direct and indirect effects*: Much is known about short term health impact of climate change. However, more information is required in the context of long term changes such as increasing drought, decline in fresh water resources and large scale migrations involving population displacement leading to diverse effects ranging from mental health impacts to risk of conflicts, especially with respect of such impact on children and other vulnerable groups. Global economic trends do indicate that four-fifths of world's population is economically marginalized. Poverty is not evenly distributed and the distribution of wealth is extremely unbalanced globally, regionally, and nationally. Substantial majority of those in the tropical and subtropical regions are poor and deprived: these are also the geographical regions and population subsets that are likely to be hit hardest by climate change. Migratory pressures from these regions into Europe, North America and Australia are likely to increase, as people seek a better life. In addition, the intra-country rural-urban migration shall be enhanced in several countries. Migrants facing isolation, hunger and deprivation may be driven to extreme actions by desperation, anger and hostility. The economic paradigm must therefore become inclusive: *sustainable development* with *sustainable security.*
- *Effectiveness of short term interventions*: Different countries have adopted a variety of approaches to deal with climate change-related health threats. A comparative outcome assessment of such diverse approaches to deal with heat waves and floods may be useful. This may provide rank effectiveness of interventions.
- *Assessing health impact of policies of non-health sectors*: There is an urgent need for rapid assessment of health implications of specific climate change prevention (mitigation) and adaptation policies in other sectors such as the negative effect of promotion of biofuels on food and nutrition security and malnutrition, and potentially positive health effects of sustainable energy and transport policies. A mention has already been made about

'collateral' damage inflicted by social conflicts. In contrast, cognizance must also be taken of 'collateral' benefits (15).

Identifying urgent and immediate research needs to generate and formulate evidence-based action is the foremost priority. To be cost-effective, such action must build interdisciplinary research capacity and capability, keeping in view the needs of low income countries that are most vulnerable to health effects of climate change. Additional financial and manpower resources are critical for the successful outcome of such efforts. It has been suggested that requisite projected investment will be very small compared with current investment in climate research, marginal compared with the economic implications of adaption and mitigation decisions, and trivial compared with the potential health consequences of unmanaged climate change or poorly designed climate policies (16).

A change to vegetarian food habits, socially, culturally and religiously acceptable to millions of people, may be a notable intervention. Methane released from animal manure and from enteric fermentation is a powerful greenhouse gas. Global average meat consumption is about 100 g per person per day, ranging from 25 g per person in low income countries to 250 g per person in more affluent countries. Parallel with the positive trend of economic growth in South Asia and Latin America, there is an increasing demand for meat. This will further increase carbon footprint of livestock production (17). Changing this trend in any country shall require national policy decisions. Likewise reducing meat consumption in high income countries is equally essential. Reducing the consumption of animal products primarily aimed at mitigating climate changes, may also have a 'collateral' benefit as by reducing the amount of saturated fat (dairy products including butter) and meat in the diet, the incidence of cardiovascular disease and bowel cancer may also start declining.

Another example relates to transport sector. Road transport is the fastest growing source of GHG

emissions. Presently, road transport accounts for nearly 14% of global GHG (18). A change to a low carbon transportation system such as increased amount of walking and cycling will not only significantly reduce GHG emission and mitigate climate change, but would also produce 'collateral' health benefits in terms of reduction in prevalence of obesity, diabetes, hypertension and coronary heart disease.

While above mentioned co-benefits may be realized on a long-term basis, short term co-benefits shall be discernable immediately. Road traffic injuries are a major cause of morbidity and mortality; worldwide they account for 1.2 million deaths each year (19). It has been suggested that replacing car use in towns and cities by walking, cycling and using public transport systems would reduce use of fossil fuels that would not only mitigate climate change but through such life style intervention may also reduce road traffic injuries, air pollution, and in India, noise pollution also! Thus, adopting a lifestyle associated with 30% reduction in CO_2 emissions has been estimated to reduce European healthcare costs by approximately €76 billion annually (20).

- *Strengthening public health systems to address health effects of climate change*. Most health systems interventions aimed to deal with climate change are built on basic public health competencies. Building and strengthening public health competencies and identifying most effective public health strategies to implement integrated preventive and promotive health interventions would not only reduce climate change-related threats but all environmental health risks.

Adverse Health Effects of Climate Change: An Indian Perspective

In the Indian perspective, such adverse health effects need to be viewed primarily in the context of extreme weather events, changes in the pattern and prevalence of infectious diseases, and drought-related problems. The most direct example of extreme weather events, especially in states such as Punjab, Haryana, Delhi, Uttar Pradesh, Madhya Pradesh, Bihar and Orissa, are intensive and prolonged thermal stress

such as heat wave conditions during the summer months. These lead to serious illness, injuries and death. A futuristic pointer based on modeling in urban population in the US suggests a substantial increase in death rates by the year 2050 (21). In this context, it may be worthwhile to recall Europe's heat wave in 2003 which adversely affected a large number of elderly subjects and caused upto 70000 deaths especially from respiratory and cardiovascular causes (22). Likewise, California heat wave of 2006 showed large increases in admission to hospitals from cardiovascular and other illnesses (23). In India, even at present, heat exhaustion and heat hyperthermia ('heat stroke') constitute significant cause of large number of admissions in several hospitals; high morbidity and mortality is well recognized in several districts where timely and effective medical management is not available. Rural areas are worst affected where health care facilities are either not available or are extremely dismal. Finally, the association between mortality and temperature may be J-shaped in many countries.

While planes of northern regions shall experience more intense and prolonged heat waves, the coastal regions are especially vulnerable to coastal surges accentuated by a combination of rising sea levels and intense storms. Cyclonic activity over the Bay of Bengal may increase disproportionately with the resultant devastation not only in coastal regions of India, but may also pose a real threat of large number of refugees (illegal migration) from low lying regions of Bangladesh.

Climate Change and Infectious Diseases

Although extensive literature has accumulated regarding the possible increase in the incidence of several infectious diseases as a result of climatic warming, we may consider insect-borne and water-borne diseases such as malaria and cholera as being most relevant in the Indian context. Use of complex integrated mathematical models indicates broad direction and potential magnitude of likely changes in the future. Such models project increases in the transmission of malaria and dengue fever worldwide (24). Temperature affects rate of pathogen maturation and replication in the mosquito, besides increasing the density of insects in warmer areas thus

leading to increase in malaria prevalence. Mosquito abundance is amplified with an over ten-fold increase with every unit increase (0.1°C) in temperature (25). Conditions conducive to enhanced malaria transmission may also result from a near doubling of atmospheric carbon dioxide (CO_2). The current level of atmospheric CO_2 is estimated as 379 parts per million (ppm) compared with the pre-industrial level of approximately 280 ppm. What is of major concern is the fact that the annual growth rate of CO_2 concentration has been greater in the last 10 years (1.9 ppm/year) compared to the last 40 years (1.4 ppm/year). Finally, a disproportionate warming at higher altitudes could extend the range of malarial zones and alter the epidemiology of malaria (26). It has been suggested that 260-320 million more people will be affected by malaria by 2080 as a consequence of new transmission zones (25).

The growth of algae in surface waters and coastal waters is temperature-sensitive. Warmer sea temperatures may result in a shift in species composition of algae toward the more toxic dinoflagellates (27). A disproportional increase in toxic phytoplankton blooms in Asia has been strongly correlated with El Niño Southern Oscillation (ENSO) cycle (28). Algal blooms also potentiate the transmission of cholera. Algae and the zooplankton which feed upon these algae provide a natural refuge to *Vibrio cholerae*. Sea surface temperature in the Bay of Bengal has been correlated with the density of algal blooms and outbreaks of cholera in Bangladesh (29).

In addition to well documented effects, it must be emphasized that assessment of future health outcome needs to take cognizance of climatic-environmental conditions never encountered in the recorded eco-history of this planet. Changes such as deforestation, when combined with climatic changes may lead to entirely unfamiliar health outcomes such as the emergence of 'new' infectious disease agents. In 1997/98 El Niño effects brought in their wake widespread respiratory illness due to haze from uncontrolled burning of tropical forests in countries as diverse as Brazil and Indonesia (30). Likewise Hurricane Mitch in November, 1998 resulted in increased flooding and landslides, bringing in its wake "clusters" of water-, insect-, and rodent-borne diseases

(cholera, malaria, dengue and leptospirosis) (31). Rodent populations are also affected by extremes of climate. Prolonged droughts may deplete rodent predators such as owls and snakes, thus increasing rodent population. Such eco-dysequilibrium may have contributed to the outbreak of hantavirus pulmonary syndrome in Argentina, Bolivia, Chile and Paraguay (32).

Global Climate change and Children's health

Attention has recently been drawn by the American Academy of Pediatrics (AAP) regarding anticipated effects of climate change on children's health (33). Due to their physical, physiologic and cognitive immaturity, children are often most vulnerable to adverse effects from environmental hazards; they are likely to be disproportionately affected by both direct and indirect adverse health effects of climate change. Developing countries, such as India, with a demographic profile of large population in younger age-group, must be sensitive to impact of climate change on children's health.

AAP recommends to pediatricians to dedicate personal and professional advocacy to the promotion and protection of children's health. It reiterates that climate change threatens the health, welfare, and future of current and subsequent generations of children. It exhorts pediatricians to incorporate consideration of the effects of climate change on health into their professional practice and personal lives in several ways, including patient education, life style practices, and political advocacy.

The above advice to pediatricians is equally relevant for physicians as well as for all health care professionals. Strengthening public health systems in every country, especially in the developing nations, is the key for successful implementation of mitigation and adaptation strategies. While mitigation (primary prevention) involves reducing GHG emission and concentrations in the atmosphere, adaptation (secondary prevention) involves developing public health strategies to minimize, or if possible, to eliminate local and regional adverse health outcomes resulting from climate change. Public awareness, public-health competencies including disease surveillance and disaster management, health infrastructure, and appropriate technologies are critical prerequisites for achieving success in adaptation

strategies. Finally, appropriate education and training of human resources in health is a key determinant in health systems performance.

Response to Climate Change in India: *Eleventh Five Year Plan (34)*

Recognizing the importance of climate change issues, the Prime Minister established a Council on Climate Change under his chairmanship in June 2007 to co-ordinate national action for *assessment*, *adaptation*, and *mitigation* of climate change.

Adaptation : The most important adaptation measure is development itself. The National Action Plan under preparation deals with key vulnerabilities, especially the impact on water resources, forests, coastal areas, agriculture, and health. The Eleventh Plan envisages that action plan for adaptation to climate change would require (i) action in the area of agricultural research to evolve varieties that can cope with likely climate changes, (ii) action to cope with likely increases in water stress (iii) action to cope with a greater frequency in natural disasters and enhanced capability of disaster management.

Mitigation: Undoubtedly, the accumulation of GHG, which is the cause of global warming, has occurred predominantly due to the emissions of industrial countries and it is therefore entirely appropriate that the burden of mitigation must fall on them. With a share of just 4% of global emissions, any amount of mitigation by India will not affect climate change. A substantial commitment to reduce emissions by the major industrialized countries is therefore required. Nevertheless, as a contribution to the global emissions reduction effort, the Eleventh Plan emphasizes intensification of measures to ensure that the emissions intensity of India's GHG continues to decline. The National Environmental Policy of 2006 requires 'equal per capita entitlements of global environmental resources to all countries'. The Indian argument focuses on *per capita emissions* rather than *total emissions* as the relevant variable, and also provides industrial countries with an incentive to reduce their level of emissions as quickly as possible.

One of the objectives of the Eleventh Plan is to reduce the energy intensity per unit of GHG by 20% from the period 2007-08 to 2016-17. Efforts have been initiated to increase access

to cleaner and renewable energy by fully exploiting existing resources (e.g., hydropower and wind power), developing nuclear power, and also supporting research in newer areas such as biofuels from agro-waste, solar energy etc. A National Solar Mission is likely to be launched in 2009.

National Concerns and International Constraints

It is most gratifying to note the expression of concern and profound display of empathy at the highest level of United Nations. The UN Secretary General Ban Ki-moon, speaking in New Delhi to the CEOs of TERI-Business Council for Sustainable Development on the 30th October, 2008, urged fostering a trilateral partnership of government and inter-governmental agencies, business houses and civil society organization, to coordinate and intensify efforts to combat the impact of climate change. Voicing concerns for the poor who feel the brunt of climate change, he said "I am going to be the voice of the voiceless and defence of the defenceless" He suggested that government policies should aim at an ambitious sealing on emissions, new clean technologies for the developing world, putting in place appropriate renewable energy targets in key areas and making enhanced investments in Research and Development so as to develop a *green economy* compatible with *sustainable development*.

The declaration at the Major Economies Forum (MEF) on Energy and Climate, 2009, includes the following key statement on limiting GHG emission: "We recognize the scientific view that the increase in global average temperature above pre-industrial levels ought not to exceed 2 degrees C. In this regard...we will work between now and [the 15th Conference of the Parties (COP-15) to the UN Framework Convention on Climate Change (UNFCCC) in December, 2009 at Copenhagen]...to identify a global goal for substantially reducing emissions by 2050." Whether this statement compromises India's earlier stand as articulated in the Eleventh Plan document, remains a matter of political debate. Nevertheless, we must take a positive view of the fact that UNFCCC identifies technology transfer (along with funding and insurance) as key actions for adaptation to climate change by developing countries. Technological challenge requires incentive for the development of technologies required to

respond to the adverse public health consequences of climate change in the developing countries. Although intellectual property rights reward innovations and discovery, undeniably these property rights also impede scientific and technological development by reducing sharing of knowledge and leading to excessive premium of costs. To ensure health equity, a rebalancing of the costs and benefits of current intellectual property regime is an essential prerequisite.

Notwithstanding the complexity of issues involved, what is absolutely clear is that while the broad contours of international policy framework are being defined, the real challenge is how to evolve a multisectoral response in which scientists, governments, international organizations and most importantly, the civil society collaborate purposefully. Fostering multidisciplinary collaboration to capacitate development in all areas will be essential. Health effects of climate change need to be monitored, mitigated, and managed more efficiently and effectively. What needs to be done by medical, health and scientific academies is to explore ways to break down traditional field-specific boundaries so that experts of all disciplines can build a global consensus which can be adopted regionally and adapted nationally.

Within the complexity of national policy framework which must internalize energy security through integrated energy policy along with inclusive growth through sustainable development, environmental concerns must be reflected and articulated on the basis of a long term perspective. In the meanwhile each individual must initiate a set of actions immediately : restrict unnecessary long distance travel (by road, rail or air); short distance local travel can be done by walking or cycling or by public transport; at home or workplace use low energy light bulbs; turn off lights, fans, computers, chargers, air conditioners etc. when not in use. In addition, buy food, milk, fruits and vegetables which are produced locally. This would discourage long distance transportation of goods. It should no longer be a matter of taste or social status to buy apples and pears from Thailand, cheese produced in Australia or Denmark, or apples imported from China. Let us be conscious of our consumption patterns: one litre of mineral water may use as much as a third of a litre of oil. Just as

a calorie calculator improves physical health, a carbon calculator improves environmental health!

Epilogue

In the report of the *Steering Committee on Health, Health Education and Biomedical Research, 1997*, I had stated:

"I visualize an entirely new health dimension emerging as we enter the twenty-first century. I do not believe that the health issues of tomorrow would be entirely amenable to the modern tools of science and technology. Genetic engineering can never be a substitute for social engineering nor can the advances in biomedical sciences counterbalance the adverse health impact of environmental degradation. High risk behaviour, altering life styles and progressive damage to the environment, shall constitute the template directing epidemiologic transition in the next century. The essence and essentials of health programmes must therefore include reduction of health risks from environmental pollution and hazards. ***The interdigitation of primary environmental care and primary health care is therefore obvious, as is the substantial synergy that exists between poverty alleviation and environmental protection"*** (35).

While in 1997 the premise articulated above may have been ahead of its time, presently there seems to be an emerging consensus that the template for the present and the coming decades shall be directed by an integration of health, environment, energy and economic policies so as to motivate and mobilize health professions who must intensify cohesive efforts to turn inert facts into informed action.

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