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The Impacts of Climate Change on Public Health: Exploring the Link to Pharmacological Knowledge and Education

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Abstract: The overall current of impact of climate change on public health, its general awareness and mapping of national policy is widely recognized. Nevertheless, some fundamental aspects have also remained underappreciated such as the impact of climatic change on plant biology, impacts of well-being of human in the ecosystem and knowledge-education in exploring the links to pharmacology. Therefore, we aim to address some of these issues linked, particularly feasible links between plant function and human health and present a list of key questions that may help to integrate plant biology into the current paradigm on climate change and human health in the pharmacology. Here, we provide a number of critical examples that range over various health concerns related to plant biology and climate change and focus of their inter-linkage of toxicology, aerobiology, contact dermatitis and pharmacology in exploring the system knowledge in plant biology. As the links among climate change, plant biology and public health that remain underappreciated by both plant scientists and health care providers; therefore, we present the degree of health risk posed by climate change and way forward to minimize adverse impacts.

Key words: Climate change, public health, impact, knowledge and education, toxicology, pharmacy, pharmacology

INTRODUCTION

The climate change issues related to environmental degradation were not considered as one of the major concerns at the time when gains from economic development and arguments on industrialization were introduced and the welfare changes associated with industrialization did not include the impact on the environment. But in this contemporary world, climate change issue is now one of the most focus points and it is already beginning to transform our ecosystem and that is well evident in the recent climate change literature (Hertel *et al*., 2010; Burke *et al*., 2009; Bonfils *et al*., 2008; Lobell *et al*., 2007; Cahill *et al*., 2007; Field *et al*., 2007). The impact of climate change issue can easily be traced by negative feedback and stern review (Stern, 2007) stated that the carbon concentration would almost double over the next 25 years compared to the pre-industrial revolution era and a million years would be needed to meet 550 parts per million (ppm) without the industrial revolution and post-era activities. The outcome approaching is the negative impact of technological mastery, which breeds dangerous consequences on the environment (Al-Amin and Leal, 2011). The scientific evidence is now irrefutable and real with fundamental scientific evidence (Lobell *et al*., 2011; Burke *et al*., 2010; Lobell *et al*., 2008; Stern, 2007; IPCC, 2007). Recently, climate change impacts are jumping potentially as a result of declining global potential sinks and unmannered increased economic activity emphasizes the critical need to characterize the probable impacts of this impending climate forcing on human systems (Canadell *et al*., 2007).

Providing negative outcomes and arguments in regards to climate change is simple and straight. A common argument is made that environment is degraded by the carbon concentration and temperature fluctuation. However, with the discourse, one key fundamental aspect has remained underappreciated: impact of climatic change on plant biology and the impacts of well-being of human in the ecosystem. Therefore, we feel necessary to

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contribute within our capability to raise this issue and where, climate change matters as an additional dimension of global environmental change. We know that there is an interrelationship between the response of terrestrial plants to the buildup of atmospheric carbon concentration, potential climatic forcing with respect to temperature on plant growth and the implications for human health and nutrition (Ziska *et al*., 2009; Canadell *et al*., 2007). Plant biology is directly affected by rising carbon concentration because CO_2 is the sole supplier of carbon for photosynthesis. Approximately 95% of all plants species are deficient in the amount of CO_2 needed to operate at maximum efficiency, recent increases in carbon concentration have already stimulated plant growth and projected future increases will continue to do so, with the degree of stimulation being at least potentially temperature dependent (Ziska *et al*., 2009).

Therefore, there is a growing concerted effort among academic and government institutions both to recognize the degree of health risk posed by climate change (Epstein and Mills, 2005; McMichael *et al*., 2006; Patz and Kovats, 2002). Worthwhile noting that the role of plant biology in human health has largely been ignored until recently. As climate change effects are quite varying from one particular region to the other, therefore, we need to consider potential causes to understand the possible planning lacking focusing on health issues. To minimize the impacts of human health in copping the climate change, we must bear in mind some fundamental concepts such as aerobiology, contact dermatitis, toxicology, pharmacology and spread of human disease. Addressing climate change effects on human health; we suffer in many ways by what may be called linking knowledge gap. We may address some of lacking for a framework on policy issue-but staking question may be challenged: do we have the proper knowledge and education related public health impacts and knowledge in exploring the links? We also suffer for plant blindness issues because we more likely to recognize the diversity of natural world and only acknowledge plants as a sort of "green background" but we underappreciated plant interactions beyond the realm of it. Yet, interactions between plant biology and public health are a facet of human-induced climatic forcing issue and that is underappreciated. However, green background-essential habitat so call plant biology linking to pharmacology is highly dynamic in the way around in addressing the issue. Therefore, we focus what should be place an effective plan to deal with the raised issues and what aspects of plant biology currently affect the public health? As the plant biology has not been fully elucidated, particularly addressing climate change and public health impacts. Likewise, knowledge and education in exploring the links to pharmacology also still partially expound. Therefore, we consider the issue and that deserve our consideration and attention in the way forward.

CLIMATE CHANGE AND HUMAN HEALTH: ISSUES

Climate change is currently diffidently affecting public health by changing in precipitation, temperature patterns and which resulting in natural climatic factors such as flooding and drought, heat waves and changes air quality. Even though there are some disputes in the time-scale of effects but the scientific evidence are real and that are anticipated to continue in the years to come (Burke *et al*., 2010; Stern, 2007; IPCC, 2007). Climate change related certain adverse health effects probably avoid if appropriate decisions and ensured access to preventive measures can place prior to vulnerability. This is a simplified illustration, but other factors must come into play in determining vulnerability including biological susceptibility and capacity of the built environment. World Health Organization (WHO) estimated 166,000 deaths and about 5.5 million disability-adjusted life years only for several diseases such as cardiovascular disease, malnutrition, diarrhea and malaria that attribute to climate change (WHO, 2003). Asthma, respiratory allergies and airway diseases become more prevalent because of increased human exposure to pollen, molds, air pollution and aerosolized marine toxins. The most affecting countries are the developing world. The vital evident we find from the majority of analyses on climate change and health care related recent researches (Portier *et al*., 2010).

There are likely health impacts results higher ambient temperatures that increase the transfer of volatile and semi-volatile compounds from water and wastewater into the atmosphere and alter the distribution of contaminants to places more distant from the sources, changing subsequent human exposures (Macdonald *et al*., 2003). No only that, other direct effect of climate change is the depletion of stratospheric ozone which results in increased Ultra Violet (UV) radiation exposure and it increases the risk of skin cancers and cataracts. This effect is compounded by several other variables including temperature and exposure to other compounds that can amplify the carcinogenic potential of UV radiation (Burke and Wei, 2009). Here, we address some of the frequent climate change and human health related consequences and provide a brief synopsis of what is

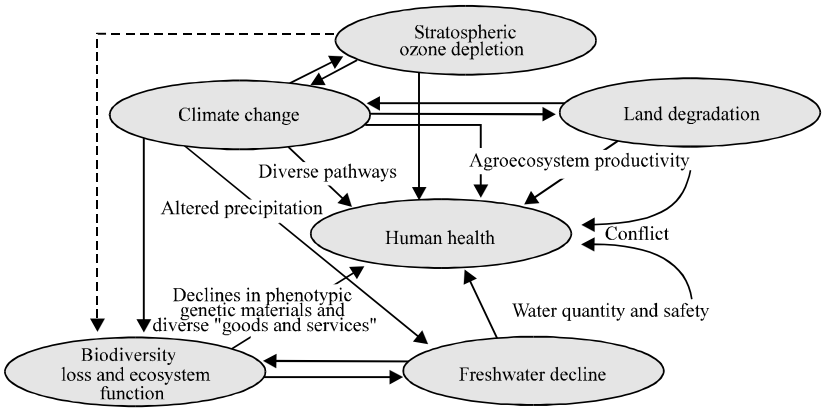

Fig. 1: Interrelationships between major types of global environmental change, including climate change and human health. Source: WHO (2003)

known about the relationship between climate change, incidence, severity, or characteristics of the specific diseases or disorders (Fig. 1).

Neurological diseases and disorders: Climate change and mitigation attempts increase the number of neurological diseases and disorders in humans. Neurological health likely attached to the aging of a large portion of the population, learning disabilities that affect children also are on the rise and there are indicators that environmental factors are involved including changes in climate that exacerbate factors affecting the rates and severity of neurological conditions (Bronstein *et al*., 2008; Altevogt *et al*., 2008). Researches in this area focus on identifying vulnerable populations and understanding the mechanisms and effects of human exposure to neurological hazards such as biotoxins, metals and pesticides and it potentially exacerbating effects of malnutrition and stress. Numerous recent reports have described observed and anticipated detrimental effects of climate change on ocean health, resulting in increased risks to neurological health (Bronstein *et al*., 2008).

Waterborne diseases: Increases in water temperature, evaporation-transpiration rates and changes in coastal ecosystem health increase the incidence of water contamination with harmful pathogens and chemicals, of pathogenic microorganisms, biotoxins and toxic contaminants resulting in increased human exposure. Waterborne microorganisms include protozoa that cause cryptosporidiosis, parasites that cause schistosomiasis, bacteria that cause cholera and legionellosis, viruses that cause viral gastroenteritis, amoebas that cause amoebic meningoencephalitis and algae that cause neurotoxicity (Batterman *et al*., 2009). There is a clear association between increases in precipitation and outbreaks of waterborne disease, as climate change is expected to produce more frequent and severe extreme precipitation events worldwide (Hrudey *et al*., 2003)[1].

Vectorborne and zoonotic diseases: Climate change and vectorborne or zoonotic diseases are interrelated. The relationship is already beginning to appear and is well evident in the recent literature by Portier *et al*. (2010).

[1]Some of the largest outbreaks of waterborne disease in North America, particularly in the Great Lakes, have resulted after extreme rainfall events. For example, in May 2000, heavy rainfall in Walkerton, Ontario resulted in approximately 2,300 illnesses and seven deaths after the town's drinking water became contaminated with *E. coli* O157:H7 and Campylobacter jejun (Hrudey *et al*., 2003).

Climate is one of several factors that influence the distribution of Vectorborne and Zoonotic Diseases (VBZD) such as Lyme disease, Hantavirus, West Nile virus and Malaria (Portier *et al*., 2010; Adler and Wills 2003). Vectorborne and zoonotic diseases risk increase as a result of climate change and it particularly expands the vector ranges, shortens of pathogen incubation periods, disrupts and relocation of large human populations. The epidemiology of vectorborne and zoonotic diseases in the world including United States has changed significantly over years and many diseases that previously caused significant illness and death (Petri *et al*., 2008; Adler and Wills, 2003). There is substantial concern that climate change would make certain environments more suitable for some vectorborne or zoonotic diseases and potentially reintroducing some diseases into geographic areas where they had been previously eradicated (Portier *et al*., 2010).

Therefore, it is evident that stresses on the climate system are already causing impacts on human health issues. This includes changes in natural ecosystems, such as poleward shifts in the distribution and inextricably linked to the health of human societies. It is widely accepted that humans are influencing by global climate change and decision makers are also focusing on the type and timing of actions to limit the rate of change (Al-Amin and Alam, 2011)[2]. Except this current discussion, we find a good number of critical examples that range over various health concerns to climate change (Ziska *et al*., 2009). Easily we find the inter-linkage between climate change and apparent health effects but how this effect can be alleviated in the long run? Here, we necessitate exploring beyond the linkage between climate change and apparent health effects. If it is possible to make further progress on climate change and health impact related alleviation knowledge, then one alternative option may take place is the explore plant biology links to human health. This option can be a potential argument issue and research question in the future pharmacology literature. As the links among climate change, plant biology and public health are remain underappreciated by scientists and health care providers until recently; therefore, in the following section we search the link.

EXPLORING THE LINK TO PHARMACOLOGY

The issue of climate change on health impact is not very novel issues. However, as the impacts are fast approaching; therefore a concerted effort among academic and government institutions to both recognize the degree of health risk and alleviate strategies to minimize adverse impacts are forthcoming. A good number of research approaches are also going on how climate change impact on health can alleviate by alternative way. One of the forefront issues here is plant biology and the linkage with pharmacology. However, in the assessments, the role of plant biology in human health has been largely ignored. As the climate change matters are continues to increase (atmospheric CO_2), the fundamental changes in plant biology either from anticipated changes in temperature and other abiotic parameters related to climatic forcing, or directly from CO_2-induced changes in physiology are changing. From the initial studies available in the literature, it is evident that there are a number of plant-based links between anthropogenic perturbations and public health (Ziska *et al*., 2009). At this point, the question is-how education and knowledge recognize the degree of health risk and alleviate strategies by blending of theoretical work and clinical experiences that meet the needs of society. This may a fruitful progress of on step further in the issue raised.

Knowledge and education: It provides an appreciation of the background and nature of the problem with the skilled processes and instructs how to dispense the pharmacology knowledge skillfully. It also emphasizes vital fact of science and technology and explains throughout the professional services in a continuous responsibility. As we know that plant biology, pharmacy, pharmacology and pharmaceutical sciences are interrelated; therefore, knowledge in the related sciences and professional areas, includes various scientific phenomena and clinical application, provide an appreciation of the background and nature of the problem to make progress on step ahead. However, when we consider the linkage the plant biology and pharmacology together with the climate change issues; yet, there are a number of key questions that remain to be addressed by the scientific community which are decently raised by Ziska *et al*. (2009). The questions are-what climate change really matters in the health care issues? What plant species are likely to increase pollen production in response to climate change? Is there any relationship with pollen production and climate change? How this affects the epidemiology of allergies/asthma? Can we expect toxicological changes in poisonous plants? Is the quality or efficacy of plant-based medicines increasing or decreasing for climate change issues? How climate change affects the pharmacy and pharmacology related technology? If plant growth is responsive to increasing carbon concentration and increased levels of

[2]Attention is shifting to the balance between the possible impacts of climate change and the economic costs, technological advances and societal adaptations that are necessary for mitigation

Table 1: A partial list of plant-derived pharmaceutical drugs and their clinical uses

Drug	Action/clinical use	Plant species
Acetyldigoxin	Cardiotonic	*Digitalis lanata* (foxglove)
Allyl isothiocyanate	Rubefacient	*Brassica nigra* (black mustard)
Artemisinin	Antimalarial	*Artemisia annua* (sweet Annie)
Atropine	Anticholinergic	*Datura stramonium* (jimsonweed)
Berberine	Bacillary dysentery	*Berberis vulgaris* (barberry)
Codeine	Analgesic	*Papaver somniferum* (poppy)
d-Pinitol	Expectorant	*Various* species
l-Dopa	Anti-Parkinson	*Mucuna pruriens* (velvet bean)
Ephedrine	Antihistamine	*Ephedra sinica* (Mormon tea)
Galanthamine	Cholinesterase inhibitor	*Lycoris squamigera* (surprise lily)
Kawain	Tranquilizer	*Piper methysticum* (kava)
Lapachol	Anticancer, antitumor	*Tabebuia avellandedae* (lapacho tree)
Ouabain	Cardiotonic	*Strophanthus gratis* (climbing oleander)
Quinine	Antimalarial	*Ciuchona ledgeriana* (Peruvian bark)
Salicin	Analgesic	*Salix alba* (willow)
Taxol	Antitumor	*Taxus brevifolia* (Pacific yew)
Vasicine	Cerebral stimulant	*Viuca minor* (periwinkle)
Vincristine	Antilenkemic agent	*Catharanthus roseus* (Madagascar periwinkle)

Sources: Ziska *et al.* (2009)

herbicides are needed for control, the how do this affect levels of pesticides in the environment? Until recently, none of these questions have been addressed in-depth analysis in exploring the linkage in the issue raised.

Toxicology and human health: Is there any relationship between toxicology and human health? What do we know from the related literature? More than 700 plant species are poisonous to human's health which can be found by the recent study by Ziska *et al.* (2009) and the presence of toxic substances is related to specific plant organs and poisonous parts can exist on the same plant. It is also very familiar in the pharmacology that hemlock (Conium maculatum), oleander (Nerium aleander) and castor bean (Ricinus communis) are extremely poisonous and a tiny amount can be fatal (Watson *et al.*, 2004). The evidence suggests that pediatric patients comprise more than 80% of plant-related exposures and few plants are associated with potentially life-threatening toxicity and less than 20% of plant[3] exposures require medical treatment (Watson *et al.*, 2004). However, the impact of carbon concentration and climate change issue on the concentration or production of such poisons is almost completely unknown (Ziska *et al.*, 2009).

The knowledge on carbon concentration and climate change issue, enhanced analysis by the pharmaceutical sciences and experiments in various scientific phenomena and clinical application can provide an appreciation of the background and nature of the problem. This branch would be the new branch of pharmaceutical sciences and by studying on this matter, health care can be benefited and more effective. However, the scientific knowledge and education is vital in this development. Plants have been used for healing since the beginning of civilization but diversity in the production of secondary chemical products is an important source of existing and new metabolites of pharmacologic interest in the pharmaceutical sciences. A partial list of plant-derived pharmaceutical drugs and their clinical uses have been shown in Table 1[4].

Therefore, it is reasonable to ask how to control any potential or probable impact of climatic forcing or carbon-induced changes in plant biology and public health. The scientists are fast approaching to explore the link from plant biology to pharmacology together with the carbon concentration and climate change issues. However, a number of difficulties in the way forward for sufficient climatological information to make accurate localized risks for climate change issues and some scientific lacking on the way forward. The evidence we find in the related literature by the recent research findings such as: Attitalla (2011), Al-Amin and Alam (2011), Sohail and Munir (2011), Mirzaei-Aghsaghali and Maheri-Sis, (2011), Zarra-Nezhad and Hosainpour (2011), Rezaie (2011), Adam (2011), He *et al.* (2011), Al-Amin *et al.* (2010), Slenning (2010), McIntyre *et al.* (2010), Nazrun *et al.* (2010), Qureshi, *et al.* (2010), Ahortor (2010), Hung-Wen and Ching-Fang (2010), Ali and Abdolazim (2010), Ostfeld (2009), Randolph (2009), Yacob *et al.* (2009), Rabia *et al.* (2009), Khorshid (2008), Sepehrdoust (2009), King *et al.* (2006), Anderson *et al.* (2004) and Curriero *et al.* (2001).

[3]For example, rhubarb, Rheum rhabarbarum and potato, Solanum tuberose, Bracken fern (Pteridium aquilinum)

[4]The synthetic drugs have replaced herbal medicines by 25% in the developed countries and in the developing countries, however, WHO reported that more than 3.5 billion people or more than half of the world's population rely on plants as components of their primary health care (WHO, 2002)

CONCLUSION

Undoubtedly, climate change is currently affecting public health by changing climate change. As the climate change, health impacts and pharmacology are significantly interrelated; therefore, we feel necessity of the effective researches on climate change and public health impacts. Detailed analytical knowledge and education are utterly vital in exploring the links from plant biology to pharmacology. This study addresses the issues raising some arguments on why and how research should address the relationship between climate change, the composition of pollutant mixtures and effects of climate change to identify the risk. We also discuss why proper scientific education and knowledge is needed to support the use of related science in understanding the link from plant biology to pharmacology. However, an integral component of developing effective risk communication and targeting the messages to vulnerable populations must be come put forward in any future research. Particularly, throughout the study we critically evaluate the extant and probable links between plant function and human health. With the help of current research and knowledge, we intend to show the importance of linking issues in the climate change impacts on human health and present a list of key questions that may help to integrate plant biology into the current paradigm on climate change and human health in the pharmacology literature.

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