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RESEARCH ARTICLE

POTENTIAL IMPACT OF CLIMATE CHANGE ON HUMAN HEALTH; BASED ON EMPIRICAL EVIDENCES AND HUMAN ADAPTATION

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ABSTRACT

Back ground: Climate change is a significant threat to the health. It is the result of the buildup of greenhouse gases in the atmosphere, primarily from the burning of fossil fuels, such as oil and gasoline, for energy and other human activities. These gases, such as carbon dioxide and methane, warm and alter the global climate. **Objective:** Climate change refers to long-term shifts in weather conditions and patterns of extreme weather events. It may lead to changes in health threat to human beings, multiplying existing health problems. This review examines the scientific evidences on the impact of climate change on human infectious diseases. It identifies research progress and gaps on how human society may respond to, adapt to, and prepare for the related changes. **Method:** The three adaptation measures are recommended: 1) to go beyond empirical observations of the association between climate change and infectious diseases and develop more scientific explanations, 2) to improve the prediction of spatial–temporal process of climate change and the associated shifts in infectious diseases at various spatial and temporal scales, and 3) to establish locally effective early warning systems for the health effects of predicated climate change. **Result:** It identifies research progress and gaps on how human society may respond to, adapt to, and prepare for the related changes. Based on a survey of related publications between 2000 and 2015, the terms used for literature selection reflect three aspects the components of infectious diseases, climate variables, and selected infectious diseases. Humans' vulnerability to the potential health impacts by climate change is evident in literature. **Conclusion:** As an active agent, human beings may control the related health effects that may be effectively controlled through adopting proactive measures, including better understanding of the climate change patterns and of the compound disease-specific health effects, and effective allocation of technologies and resources to promote healthy lifestyles and public awareness.

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INTRODUCTION

The climate change phenomenon refers to seasonal changes over a long period with respect to the growing accumulation of carbon dioxide and other greenhouse gases in the atmosphere. Climate change, also called global warming, refers to the rise in average surface temperatures on Earth. Climate change is the result of the emission of greenhouse gases in the atmosphere, primarily from the burning of fossil fuels, and other human activities.

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These greenhouse gases, such as carbon dioxide and methane, warm and alter the global climate. The changes in temperature and precipitation, as well as other changes, such as more intense severe weather and rising sea levels, all have effects on people's environments that can in turn harm their health and well-being. Climate change is a significant threat to human health. According to the Prediction of Intergovernmental Panel on Climate Change (IPCC) it is expected that during 21st century the average temperature will rise up to 5.8°C across the world, resulting in strange and extreme weather events in the form of heat-waves, drought and floods (IPCC, 2001). Global changes in pursuing the sustainable development are main problems for human

population (Weng *et al*., 2013; Yang *et al*., 2013). Climatic changes are significant threat for the health of human being (Costello *et al.*, 2009; Willox *et al*., 2015), particularly concern the hazards of infectious diseases (Altizer *et al*., 2013; Bouzid *et al*., 2014). The three main categories of climate change impact on human health are:

- Direct impact (e.g. as a result of heat waves, large-scale air pollution, natural disasters).
- Impact on ecosystems and environmental relationships (e.g. damage to agricultural crops, overabundance of mosquitoes and depletion ofmarine species).
- Indirect impact (e.g. poverty, displacement, conflict over resources such as water, post-disaster epidemics).

The indirect effects of climate change on human health associated to the changes in air pollution levels depends on future climate. Accordingly, changes in the meteorological conditions temperature, humidity, wind speed, wind directions and precipitation that may ascot the future climate and can deeply impact on air quality. As a result, climate change threatens to reduce, impede or reverse global progress for those suffering from malnutrition and dying of infectious diseases, especially in developing regions of the world.It is also expected that climate change will affect epidemiology of many diseases (outbreak, spread and control of infection diseases), as well as physical and mental health and hygiene conditions ofsociety and individuals. The rising trend of climate change is shown in recent reports by the United Nations' Intergovernmental Panel on Climate Change (IPCC), that nearly half of the world's population is at risk of vector-borne diseases, which account for more than 17 percent of all infectious diseases and cause more than a million deaths annually [Seventieth World Health Assembly update, 30 May 2017].CDC. World Health Day Vector-borne diseases. 2014d. [October 20, 2014]. http://www .cdc.gov/features/worldhealth day2014.

Three components show vital role for spreading the human infectious diseases: a pathogen (agent), Vector (host) and suitable environment for transmission (Epstein, 2001a). Some pathogens are carried out by vectors or need an intermediate host for completion of their lifecycle. Suitable climatic conditions are required for their existence, growth, distribution, transmission and living environment of pathogens, host and vectors. These favorable climatic conditions strongly effects in spreading the human infectious diseases (Epstein, 2001a; Wu *et al*., 2014). Studies have also shows that long-term global warming help in increasing the geographic expansion of human infectious diseases (Ostfeld and Brunner, 2015), similarly, in many regions of the world rate of clustered diseases also increase due to extreme weather events (Epstein, 2000). In general, climatic variable situation hinder the distributions of infectious diseases, and also affects on the outbreaks of infectious diseases such as timing, duration and concentration of diseases (Kuhn *et al*., 2005; Wu *et al*., 2014). Several most common human infectious diseases transmitted by insects, are highly responsive to climatic variations (Kuhn *et al*., 2005; Tian *et al*., 2015a). Climatic variations may lead to dramatic increases in prevalence of a variety of infectious diseases. Beginning in the mid-'70s, there has been an "emergence, resurgence and redistribution of infectious diseases". New resurging vector-borne infectious diseases are dengue, hantavirus, cholera and malaria (Tian *et al*., 2015b; Yu *et al*., 2015). Similarly, more infectious diseases, like salmonellosis (Chretien *et al*., 2014), cholera and giardiasis, also increase the rate of spreading risk due to change in temperature and flooding. This study based on literature review on the basis of scientific evidences and showing the potential impact of climate change on human health in terms of infectious diseases. Aim of this study is to examine the predicted and observed impacts of climate changes with weather concentrations and extreme weather events on agent (or pathogen), a host (or vector) and transmission environment to deliver infectious diseases in human being.

MATERIALS AND METHODS

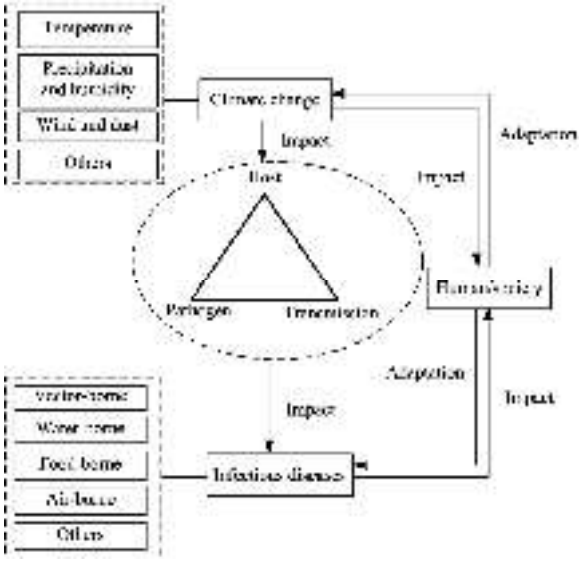
As mentioned earlier that, three components show vital role for most infectious diseases: an agent (or pathogen), a host (or vector) and transmission environment. Human being plays an active part during the process of transmission and can diminish the impact by changing in adaptation strategies as recommended by Kovats *et al*. (2000). Figure-1 shows the links between climatic changes, infectious diseases and their effects on human society, making a skeletal network which helps in-search of literature for this review article. Three steps were used to describe the searching ofliterature survey in this study for the related study. The first step describes the components of diseases: an agent (or pathogen), a host (or vector) and transmission environment for diseases. The second step describes the climatic conditions, metrological conditions (e.g humidity and temperature), major events of extreme weather and tremendous weather events (e.g flood, drought and heat waves).

The third step describes the infectious diseases, like vector-borne diseases (i.e malaria and dengue fever), water-borne diseases (i.e cholera), air-borne diseases (i.e influenza), or food-borne diseases (i.e Campylobacter). An inclusive literature survey was carried out by searching the Web sites of Science/Knowledge, Google Scholar (http://scholar.google.com), Elsevier Science Direct (http://www.sciencedirect.com/), Springer Online Journals (http://link.springer.com/) and CNKI (http://www.cnki.net/). The study was focus on the different peer-reviewed articles and various government reports during the year 2000 and 2015. Various relevant reports of World Organization for Animal Health (OIE), IPCC, United Nations Development Programmed (UNDP), United Nations Environment Program (UNEP), Pan American Health Organization (PAHO), World Health Organization (WHO) and Interagency Working Group on Climate Change and Health (IWGCCH) were also included in this review. More than 100 publications have been reviewed for this study, sharing the information about the potential effects of climate change regarding the pathogen (agent), vector (host) and atmospheric environment for transmission of infectious diseases in humans.

Climate Change And Infectious Diseases: Climate changes create alterations in climatic variables like humidity, temperature, wind speed, wind direction and sunshine. Changes in these climatic variables may impact on the survival, reproduction, or distribution of disease pathogens and hosts, and also depends on the availability and ways of their transmission environment. The health effects of such impacts liable to expose as change in the geographical and seasonal patterns ofhuman infectious diseases, their outbreak frequency and their severity.

Climate Change and Pathogens (Agents): Pathogens are the agents of disease, including parasitic germs, virus, bacteria, Fungi and protozoa. The impact of climate change on pathogens can be direct, through influencing the survival, reproduction and life cycle of pathogens, or indirect, through influencing the habitat, environment, or competitors of pathogens. Resulting, the seasonal and geographical distribution may change the quantity of pathogens. Temperature variations affect the life cycle of pathogens (agent) which ultimately affect the diseases transmission. Firstly, a pathogen required a definite range of temperature to develop and stay alive. For example, maximum temperature up to 22–23 °C required for the growth of mosquito and minimum temperature from 25–26 °C required to spread the Japanese Encephalitis Virus (JEV) in the environment (Tian *et al*., 2015a) whereas, mortality rate of pathogens (agent) increases during extreme heat event (Kuhn, *et al*., 2005). Due to which, the growth of malaria parasite (Plasmodium falciparum and Plasmodium vivax) ceases during hot summer days when the temperature exceeds from 33°–39 °C. Secondly, increasing trend in temperature can change the growth and extrinsic incubation period (EIP) of pathogens (Harvell, *et al*., 2002). Such as, the EIP of malarial parasite (P. falciparum) decrease by changing the temperature as 26 days at 20 °C and decrease up to 13 days at 25 °C (Bunyavanich, *et al*., 2003).

On the other hand, decreasing trend of ambient temperature is liable to lengthen the EIP, which may reduce the spreading of infectious diseases such as dengue fever because smaller number of mosquitoes can survive at low temperature. Thirdly, the hot weather period is responsible to increase the temperature of the atmosphere and provide a perfect / suitable environment for the growth of algal bloom and different microorganisms.



Campylobacteriosis and Salmonellas are food born diseases. Campylobacteriosis food born disease, caused by the thermophilic *Campylobacterspp* bacteria. It is the most commonly reported gastrointestinal bacterial disease. Salmonellas caused by the *Salmonella spp* bacteria, in hot summer season when the temperature becomes up to 37^0C, the reproduction of this bacteria also shows the increase rate of reproduction (IWGCCH, 2010). Climate change is a reason of precipitation, which produce the propagation of water-borne pathogens (host).

Rainfall is also an important factor for the development of pathogens of water-borne diseases. In rainy season number of fecal pathogens increases, because heavy rain stir up the sediments with water and leads to accumulate the increasing number of fecal pathogens/micro-organisms, causing the water born diseases (Hofstra, 2011; Jofre *et al*., 2010, Semenza and Wilby *et al*., 2005). Humidity changes in the atmosphere also effect on the growth of pathogens causing human infectious diseases. Air-borne human infectious disease such as influenza depends on humidity condition. For example, humidity and temperature absolutely affect the transmission and survival of influenza virus (Xu *et al.*, 2014). Wintary season and low level of humidity produce favorable conditions for spreading this virus of influenza (Lowen *et al*. 2007). Humidity also effect on the viruses of water-borne infectious diseases (Patz *et al*., 2003). It affects on the development of malarial parasite in Anopheline mosquito (Patz *et al*., 2003). Sunshine is an additional important climate erratic factor that may also change the pathogens of human infectious diseases.

For example, during cholera season, hours of sunshine and recorded temperature synergistically proceed and provide favorable circumstances for the reproduction of the virus like vibrio-cholerae in the aquatic environments (Islam *et al*., 2009). Wind speed and wind direction are key factor responsible for carrying the pathogens (agents) of air-borne diseases. Literature survey also shows a strong relation between dust particle and virus transportation. Literature also suggested that during Asian dust storm (ADSs) the atmospheric desert dust is closely linked with the increased growth of cultivable fungal spores, fungi and bacteria (Griffin, 2007). Similarly the concentration of influenza virus found significantly higher during the ADS days than normal days (Chen *et al*., 2010). Further studies described that human infectious disease virus can also be traveled from one region to another or across the ocean by dust particles (Griffin, 2007).

Climate Change and Vectors (Hosts): Vectors are living organisms that can transmit infectious diseases between humans or from animals to humans. The main focus of this review is on animal hosts, especially insects. The geography (conditions, locations and population of that area) and host (insect) are coupled with the climatic variations. Thus, the climatic changes results the change in the intensity, duration, source and types of human infectious diseases by the impacts on disease host vectors. Temperature variation is a factor responsible to change the spatial–temporal distribution of disease host vectors. By increasing the degree of temperature, the insects found in the region of low-latitude may start to shift in the region of mid or high-latitude and high altitude resulting the shift or expansion of human infectious diseases. Recent research also shows that several vector-borne infectious diseases, like malaria, Lyme disease, yellow fever, African trypanosomiasis, tick-borne encephalitis, plague and dengue are widely spreading in these days (Harvell *et al.*, 2002). Due to global warming issues, the disease hosts may shift or disappear or control, such as Anopheles-borne falciparum malaria generally grow at above the temperature of 16°C (Beck-Johnson *et al*., 2013), whereas, the temperature below this threshold limit favor to control the disease of malaria. Variations in precipitation may also impact on vectors (hosts) of diseases.

Rainfall closely associated with several vector-borne human infectious diseases such as larval growth of some mosquito vectors (host) accelerates during rainy season and during the period of high temperature days (Hoshen and Morse, 2004). A vector of malaria, Adult Anopheline commonly grow in natural clean water ponds but in droughts quantity and quality of breeding may also decreases due to which growth of mosquitoes vector (host) and transmission of disease also decreases (Gage *et al*., 2008). At all the time rainfall is not in favor of vectors for breeding. Extreme precipitation may also have terrible impacts on mosquito breeding whereas heavy rain may brush off the breeding points of vector (Kuhn *et al*., 2005). Various disease hosts show strong association with humidity changes. Relative humidity impact on the activity and survival of mosquitoes breeding and can also effects on the transmission of malarial disease in humans. Generally high humidity with low temperature favor the vectors whereas, low humidity with high temperature, produce unfavorable circumstances for ticks and fleas (grasslands or forestlands), decreasing the spread of human infectious diseases (Gage *et al*., 2008). Wind speed and directions have both positive and negative impacts on the vectors/hosts of diseases and also effects on malaria cycle. In positive manner high / strong wind speed increase the flight distance for mosquitoes in negative manner decrease the biting of opportunities mosquitoes. Similarly, during rainy season, wind can also change the distribution pattern of mosquitoes in the atmospheric environment (Reid, 2000). Sunshine is a factor that can effect on a disease host by its synergistic role. Analysis of cholera cases occurrence in Bangladesh investigated that increase in temperature with persistent sunshine increase the occurrence of cholera disease (Islam *et al*., 2009). Particularly, high temperature and average/medium sunshine hours produce favorable situation for cholera epidemic. Rather than low temperature and long hour sunshine may also still support cholera vector.

Climate Change and Disease Transmission: Diseases can be transmitted directly or indirectly in human body system. Direct transmission is the transmission of a disease from one person to another through droplet contact (moisture expelled from the upper respiratory tract through sneezing or coughing), through physical contact (both direct and indirect way), through air-borne contact and through fecal–oral contact. Indirect transmission is the transmission of a disease to human being by other different organisms like vector or any intermediate host. Several researches have proved that climate changes and weather variables may effects on disease transmission, in spite of uncertainty about a definite mechanisms. Temperature variations in the atmosphere by yourself, or together with other meteorological changes such as rainfall, may change the mode of way of the disease transmission of infectious diseases. A number of studies have reported an association between temperature variations and malarial disease transmission in African highlands (Bouma, 2003). In Africa and Kenya highlands hospital admissions of malaria patients closely associated with rainfall and with high temperature occurrence (Githeko and Ndegwa, 2001). Similarly, Hemorrhagic fever that cause Renal disorders is closely related with all meteorological variables like rainfall, humidity and temperature (Xiao *et al*., 2014). Wind velocity, wind directions and dust storms are also responsible for the transmission of human infectious diseases. Dust storm, wind directions and velocity of wind act as a means of transportation for bacteria, pathogen and virus of airborne human infectious diseases. Pathogens can transmit from one region to other region by dust storms. Similarly, in winter season virus of human influenza transported from Asia to the America by existing prevailing the wind direction and speed. Climate change can also change the transmission of human infectious diseases by varying the patterns of contact with humans like, human–pathogen (agent), human– vector (host), human–pathogen (agent) and atmospheric environment. Research shows that transmission of diseases by rodent may increase during heavy floods and heavy rainfall due to alteration in the contact of human–pathogen–rodent. Climatic variations are important factors in determining the behavior and patterns of human and other host activities (e.g migration, winter -summer habit and habitat, seasonal lifestyle and physical activities) (Viboud *et al*., 2004); which in turn drastically change the patterns of transmission of infectious diseases (Kuhn *et al*., 2005). In Europe the seasonal incidence of influenza infection strongly related to resident that spending longer hours in the indoor environment during winter season (Lofgren *et al*., 2007). Local poultry markets during the holiday period are a major source of transmission of avian influenza viral infection in human body system (Wang *et al*., 2014). A cross-sectional study regarding the incidence of diarrheal disease in the children below the age of five years shows a negative co-relation between rainfall and diarrheal infection, pointing out that diarrhea is a waterborne diseases spread by drinking of contaminated or unprotected water and careless handling during scarcity of water (Lloyd *et al*., 2007). As global warming will resulted in water scarcity and will also become a cruel issue in the world, may escort to more diarrheal infection cases in world (Lloyd *et al*., 2007). If the climate change continues producing shortage of clean surface water and may become prevalent for water-born diseases (CDC, 2010). Climate change can damage the immunity and susceptibility of humans to infectious diseases. It may also effects on the ecosystem, which will probably produce pressure on production of agriculture, causing a number of issues such as crop failure, starvation, malnutrition, migration of population and resource divergence. These pressures increased vulnerability to human infectious diseases.

Extreme Weather Events and Human Infectious Diseases: Extreme weather events mean a weather or climatic change that includes unusual, unexpected, unpredictable or unseasonal weather. Extreme weather events mainly depend on the weather history of that location which includes local and regional scale meteorological hazardous effects on human health (e.g., drought, heat waves and floods). These extreme weather events are exceptional and happen not as much of 5% of the time in the past (Zhu and Toth, 2001), but the frequency and intensity of these events are rising due to global climatic changes on the earth. Extreme weather events are commonly occur due to drastic change in climate variables (temperature, humidity and wind) and can change the impact of pathogens/agents, vectors/hosts, or transmission routes for human infectious diseases. Table 1 shows the list of literature survey carried out to examine the effects of extreme weather events and meteorological hazards on human infectious diseases. Most of the literature based only on empirical studies, missing a comprehensive mechanism to understand the incidence of extreme weather events, as how weather variables change and how they affect on human infectious disease

transmission. It is necessary to organize an inclusive mechanism to understand the changing patterns in weather conditions, intensity of climatic variables and there effects causes due to any extremeweather event. Awareness about the mechanism is a foundation in the prediction of health hazards of infectiousdiseases on human being during any extreme weather events. According to the research of Lubchenco and Karl (2012), firstly we must know that how frequently and how many changes likely expected in climatic variables for extreme weather events forecast and then secondly predict the impacts on human infectious diseases and to make guidelines for safe and healthy environment.

Societal Response and Factor: It is very important to explain that social response and economy are the factors that play a key role in the prediction ofhuman infectious diseases produce by the climatic changes on the earth (Wu *et al*., 2014). Climate change on a global scale affect on human health and welfare of all the society, but some regions and population groups are found more vulnerable due to the impact ofclimate changes (Wang, *et al*., 2014). Vulnerability depends on the surveillance programs and steps to take measures that decrease the burdens of climatic effects, susceptible health outcomes and determinants, produce the accessibility ofsafe water and enhance the sanitation system, bio-security and arrangement of surveillance programs to classify and control the human infectious diseases (Bai, *et al*., 2014). In India, mushroom growth of population, unplanned urbanization are the contributing factor for the spreading the dengue fever and P. vivax malaria (Shah *et al*., 2004) Similarly morbidity rate of diarrhea also increases due to scarcity of water, the population who are constrained water access may be highly vulnerable population to diarrheal disease (Lloyd *et al*., 2007). In any society, vulnerability due to climate change related health hazards of infectious diseases associated with its existing public health facilities and system and health infrastructure. In developing countries several infectious diseases break out after passing tropical cyclones, but this is exceptional in the developed countries.

Developing countries are at high health risk by climatic changes due to the poverty, lack of development funds, resources and capabilities of health care system for their population. Vulnerability to changing the hazards for human infectious diseases can be reduced by taking proper safety measures. For example, improved drainage system, reforestation, building sea walls and desalinization are the recommended safety measures to help the society for minimizing the impacts of climate changes (UNEP, 2013). With respect to epidemic malaria, different types of public health awareness programs have to organize in the majority of African places to decreases the rate of mortality and morbidity. It is also predicted that climatic variations may one of the possible reason or source to spread the malarial infection in some highland areas. In order to control these malarial diseases various public health program should be implemented in these highland areas, based on the cost of environmental growth of the vector/host (Wu *et al*., 2014). By taking various adaptation measures can be up-dated the weather forecasting system, including hot summer days or extreme weather events and meteorological hazards. By means of an early warning system of weather forecast, the population can mentally and physically be prepare for climatic changes related health hazards. The warning programs include public education, awareness about the climate change effects which is useful in controlling and reducing the hazards ofdiarrheal and vector-borne infectious diseases. As a result of awareness program fewer number of affected children hospitalized suffering with severe diarrheal disease. Another example of a successful weather forecasting system is also the decreasing number of patients suffering from malarial disease in Botswana (Thomson *et al*., 2006). However, early warning ofweather forecasting system is not always useful in the view of our limited knowledge about climate changes, especially about extreme weather events and meteorological hazards (Lubchenco and Karl, 2012).

CONCLUSIONS AND DISCUSSION

Climatic changes on the globe ofearth produce variations in weather conditions and create extreme weather events. The health hazards of climatic changes (climatic changes and extreme weather events) on human being include various infectious diseases are mainly created due to impacts on pathogens, hosts/vectors, and disease transmission. Firstly, list of human infectious disease classified due to climatic variations. Changes in climatic variables have profound effect on the growth, reproduction, livability and survival of infectious pathogen (agents), vector (host) and transmission in human being. Secondly, unexpected and dramatic changes in weather variables (temperature, humidity, wind speed & direction) due to extreme weather events have a great effect on human infectious diseases. Humans are most affected recipients of health hazards due to climatic changes on the earth. We can play an active role to manage, to improve and to control the negative impacts of climate change on human health by taking different protective measures. Firstly, the level of changes in climatic conditions posing stresses and challenges for human society and atmospheric environment. These climatic changes are also responsible for the induction of human infectious diseases. Secondly, at the same level of climatic variations, several groups of population and regions become vulnerable up to high level hazardous effects due to lacking of awareness. Realizing that, human infectious diseases not only stop with in a vulnerable group of population but also impacts on human societies. Developing countries should contact to developed nation and skilled population groups to control or decrease the vulnerability due to climatic variations hazards. Thirdly, vulnerability to changing the hazardous effects for human infectious diseases can be distorted by taking suitable adaptation measures. Example of adaptation measure is to properly and smoothly organize public awareness health programs and to regularly allocate financial resources and health care funds following the scientific shelfofsequential changes in health hazards for human infectious diseases. Early warning systems also help the societies or population to take proactive measures in order to prevent or control the possible impacts on human health.

This literature review clearly shows that the issues linked with the health hazards of climatic variations and the effects of climatic variations on human infectious diseases are two scientific investigation groups. One group examine the problems occur during climatic changes, in order to predict that what variables will change and produce elevated health hazards for human being. Whereas, the other group trying to investigate the range ofvarious climatic variables (humidity, temperature, wind velocity and direction) and weather

conditions (extreme weather events) that are favorable or not for certain disease pathogens (agent), vectors (host) and transmission environment to be active. There is a need of association among these two groups to understand the patterns of climatic changes and weather forecast for the risk of human health hazards by various infectious diseases. There is also a need of direct connection between the prediction of climatic variation and the level of changing the variations in weather conditions (how and when these changes occur) and may impact the hazards for human infectious diseases. A marriage of these two connections can raise the efficiency of proactive adaption measures to minimize and control the harmful health effects by climate changes. We hope this review can serve as a platform for more cross-disciplinary collaborations to map out the schedule and level of climatic variables and theses variations induced health hazards. Through this literature survey it is also observed that most of the studies are empirical nature that shows an association between climatic variations and risk for human health. Several studies revealed the empirical relation between the incidence of weather conditions (Extreme weather events) and morbidity and mortality rate due to infectious diseases. But a number of studies rejected and fail to have a say a definite correlation between climatic variables and health risks by these climatic variables. Results of this review shows that literature do not always agreed with the relations of climate change and health hazards, probably due to limiting scientific knowledge/ evidence about the net – outcome of climatic variations and their effects on human health, because three aspects (pathogen, vector and transmission) of infectious disease may effects in diverse manners. For example, relative humidity effect on air-borne transmission diseases in three manners (Lowen et al., 2007). In the first manner relative humidity acts on the vector (host) showing that low concentration of relative humidity makes the vector (host) more vulnerable for pulmonary viral infections and cause dehydration of nasal mucosa, damage of epithelial cells and dropping the muco-ciliary clearance. In the second manner relative humidity acts on the virus particles showing that high concentration of relative humidity would smash the strength virus, that is main factor of virus transmission. In the third manner relative humidity acts on the ways of virus transmission that are respiratory droplets. Droplets sizes are commonly less than 5µm in diameter, with high relative humidity they increase in quantity, can remain airborne for a longer period of time and also increases the rate of transmission of pathogens (Bridges *et al*., 2003).

Climate changes produce health risk for human infectious diseases. For controlling the vulnerability by climatic changes can be reduced by taking various adaptation measures for any human society. The most valuable adaptation measures are advancement in scientific knowledge and social contact. Firstly, the advancement in scientific knowledge is needed between climate change and infectious diseases for more descriptive conclusions. This advancement of explanation depends on our awareness about the health hazards of human infectious diseases; and also depends on health effects induced by climate changes. Secondly, there is a need to understand the spatial– temporal method of climatic variations (as, extreme weather events and meteorological hazards) by modeling and mapping, which is the base for health impacts prediction and for suitable adaption measures. In this regard, we have a comprehensive global map of changes in climate variables. Lastly, an early warning system for the prediction of health hazards due to climate change should be established. Related to such early warning systems, protocols are needed for information sharing, public health awareness campaign, and resources sharing and relocation.

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