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Optimization of Health Care Service under a Changing Climate

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Abstract: Climate change poses a serious threat to public health and well-being worldwide. Disease incidence and mortality can be affected, both directly and indirectly by climate change across a wide range of conditions. The long-term good health of populations depends on the continued stability and functioning of the biosphere's ecological and physical systems, often referred to as life-support systems. Effects of climate change on health will impact on most populations in the coming decades and put the lives and well-being of billions of people at increased risk. IPCC states that "climate change is projected to increase threats to human health". Humans have successfully adapted to environmental change over time, from evolving natural physiological responses to the use of science, technology, and knowledge to improve our lives and advance our health. From the dawn of the industrial age, people have made great strides in improving health, and enjoy a markedly improved quality of life. However, these improvements have come at a cost that must now be understood and addressed. Climate change will force humans to negotiate with their changing environment as never before to find ways to reshape it both for short-term protection and long-term alleviation of health consequences.

Keywords **-** Intergovernmental Panel on Climate Change (IPCC), Mortality, Physiological, Ecology, Paleoclimatology

I. INTRODUCTION

The ecology and environment of the world are changing due to the shifting patterns of meteorological factors. This is obvious from the 10 warmest years on record since 1998. Among them 2010 was the warmest since the global records began in 1850. Such changes in meteorological variables are already adversely affecting health. This might limit some of the existing plans & policies and capacity of health care facilities (e.g., Hospital, health care centres) and logistics.The overall state of the global climate is determined by the amount of energy stored by the climate system, and in particular the balance between energy the Earth receives from the Sun and the energy which the Earth releases back to space, called the global energy balance. How this energy balance is regulated depends upon the flows of energy within the global climate system. Major causes of climate change involve any process that can alter the global energy balance, and the energy flows within the climate system. Causes of climate change include changes in the Earth's orbit around the Sun, changes in the amount of energy coming from the Sun, changes in ocean circulation or changes in the composition of the atmosphere. Large volcanic eruptions can affect the global climate over only a few years. By contrast, the movement of continents around the world over hundreds of millions of years can also affect global climate, but only over these much longer scales. Climate change affects every aspect of society, from the health of the global economy to the health of our children. It is about the water in our wells and in our taps. It is about the food on the table and at the core of nearly all the major challenges we face today.

Climate is the long-term statistical expression of short-term weather. Climate can be defined as "expected weather". When changes in the expected weather occur, we call these climate changes. They can be defined by the differences between average weather conditions at two separate times. Climate may change in different ways, over different time scales and at different geographical scales. In recent times, scientists have become interested in global warming, due to mankind's impact on the climate system, through the enhancement of the natural greenhouse effect. Throughout the Earth's history climate has fluctuated between periods of relative warmth and relative cold. Palaeoclimatology is the study of climate and climate change prior to the

period of direct measurements. Direct records of temperature and other climatic elements span only a tiny fraction of the Earth's climatic history, and so provide an inadequate perspective on climatic change and the evolution of the climate today and in the future. A longer perspective on climate variability can be obtained by the study of natural phenomena which are climate-dependent. Such phenomena provide a record of past climates, and are revealed through the study of, amongst other techniques, tree rings, ice cores and sediments. Causes involve any process that can alter the global energy balance between energy coming from the Sun and energy leaving the Earth. There are many natural causes of climate change, but recently we have become concerned with the effect mankind's pollution of the atmosphere may be having on the global climate.

II. COMPARATIVE EFFECTS OF CHANGING CLIMATE

The Earth has a natural greenhouse effect which keeps it much warmer that it would be without an atmosphere. Greenhouse gases in the atmosphere trap infrared heat energy trying to escape back to space. In doing so they raise the temperature of the lower atmosphere and the Earth's surface in contact with it. During the last 200 years, mankind has been releasing substantial quantities of extra greenhouse gases to the atmosphere, through the burning of fossil fuels and deforestation. These extra gases are trapping more heat in the atmosphere, and it is now suspected that the observed warming of the Earth by about 0.6°C since the late 19th century is due to this man-made enhancement of the natural greenhouse effect. This climatic trend has become known as "global warming", and may be distinguished from historical and prehistorical climate changes that have occurred naturally. The term "global warming" is usually reserved for the observed global climate change during the last 100 to 150 years that is believed to be related to mankind's enhancement of the greenhouse effect. In the last 100 years or so, the Earth's surface and lowest part of the atmosphere have warmed up on average by about 0.6^{o}C. During this period, the amount of greenhouse gases in the atmosphere has increased, largely as a result of the burning of fossil fuels for energy and transportation, and land use changes, for food by mankind. In the last 20 years, concern has grown that these two phenomena are, at least in part, associated with each other. That is to say, global warming is now considered most probably to be due to the man-made increases in greenhouse gas emissions. Whilst other natural causes of climate change, including changes in the amount of energy coming from the Sun and shifting patterns of ocean circulation, can cause global climate to change over similar periods of time, the balance of evidence now indicates that there is a discernible human influence on the global climate.

Recognition that human health can be affected by a wide range of ecological disruptions, consequent upon climate change, is a recent development, reflecting the breadth and sophistication of modern scientific knowledge. Nevertheless, the simpler idea that human health and disease are linked to climate probably predates written history. The Greek physician Hippocrates (about 400 BC) related epidemics to seasonal weather changes, writing that physicians should have "due regard to the seasons of the year, and the diseases which they produce, and to the states of the wind peculiar to each country and the qualities of its waters". He exhorts them to take note of "the waters which people use, whether they be marshy and soft, or hard and running from elevated and rocky situations, and then if saltish and unfit for cooking," and to observe "the localities of towns, and of the surrounding country, whether they are low or high, hot or cold, wet or dry and of the diet and regimen of the inhabitants". Two thousand years later, Robert Plot, Secretary to the newly-founded Royal Society in England, took weather observations in 1683–84 and noted that if the same observations were made "in many foreign and remote parts at the same time" we would "probably in time thereby learn to be forewarned certainly of divers emergencies (such as heats, colds, deaths, plagues, and other epidemical distempers)".There is now widespread consensus that the Earth is warming at a rate unprecedented during post hunter-gatherer human existence. The last decade was the warmest since instrumental records began in the nineteenth century, and contained 9 of the 10 warmest years ever recorded. The causes of this change are increasingly well understood. The Third Assessment Report of the Intergovernmental Panel on Climate Change, published in 2001, goes further than its predecessors, stating that *"There is new and stronger evidence that most of the warming observed over the last 50 years is likely to be attributable to human activities",* most importantly the release of greenhouse gases from fossil fuels. Stresses on the climate system are already causing impacts on Earth's surface. These include not only rising surface temperatures, but also increasingly frequent floods and droughts, and changes in natural ecosystems, such as earlier flowering of plants, and poleward shifts in the distribution of several species. All of these changes are inextricably linked to the health of human societies. Climatic conditions affect human well-being both directly, through the physical effects of climatic extremes, and indirectly, through influences on the levels of pollution in the air, on the agricultural, marine and freshwater systems that provide food and water, and on the vectors and pathogens that cause infectious diseases.

As it is now widely accepted that humans are influencing global climate, decision makers are now focusing on the type and timing of actions to limit the rate of change. 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.

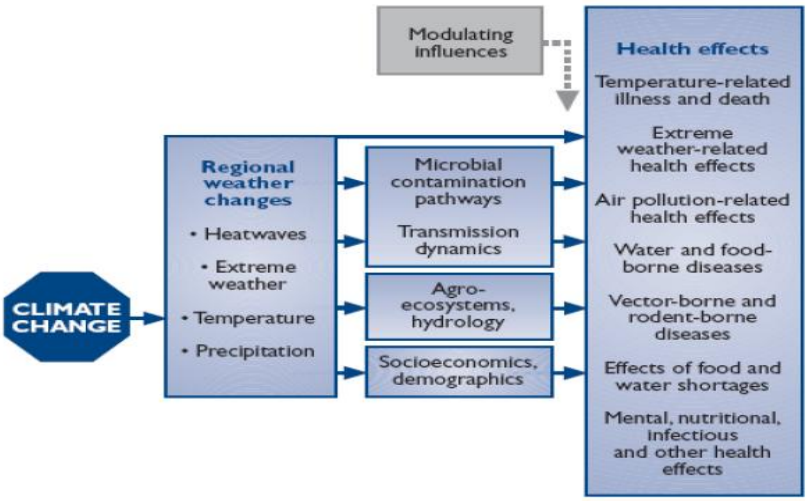
International agreements, supported by hard science, are proving effective in combating wide-ranging environmental threats such as ozone depletion and long-range trans boundary air pollution. Can similar agreements be implemented to address the more complex risks posed by global climate change? Scientific analysis in general and the health sector in particular, need to inform and help advance ongoing policy discussions. Firstly, the scientific community must produce rigorous and balanced evidence not only of the breadth and magnitude of climate change effects, but also of how they are distributed across populations, and over time. Just and equitable decisions on appropriate responses to climate change can only be reached by giving consideration to all those affected by policy actions (or inactions), including future generations. Secondly, as some degree of continued climate change is now inevitable, it is necessary to identify vulnerable populations, and formulate policies and measures to help them adapt to changing conditions.

III. THE IMPACTS OF CLIMATIC CHANGE ON HUMAN HEALTH

i. Climate Change and Human

Climate change affects population health via a host of factors with complex interrelationships, including exposure, socio-economic status, the built environment and cultural practices, as depicted that result in diverse health consequences, most of which are adverse (Maibach et al, 2011; McMichael et al, 2003; Patz, 2000). Modulating influences which can help to buffer the impact of extreme weather events include access to good health care, proper urban planning, and proactive Surveillance and monitoring systems

Figure 1: Pathways by which climate change affects population health



Source From: (McMichael, A. J et al, 2001).

ii. Health Consequence of Climate Change

Climate-related ecosystem changes: It can increase the range, seasonality, and infectivity of some waterborne diseases, such as cholera and diarrhoea diseases, malaria fever, many of which are highly sensitive to temperature and rainfall. Changing temperatures and patterns of rainfall are expected to alter the geographical distribution of insect vectors that spread infectious diseases.

Rising temperatures and more frequent droughts and floods: It can compromise food security. Increased malnutrition is expected to be especially severe in countries where large numbers of the population depend on rain-fed subsistence farming.

Malnutrition, much of which is caused by periodic drought, is already responsible for an estimated 3.5 million deaths worldwide each year. This has severe implications for child growth and development (Intergovernmental Panel on Climate Change, 2007) and could negatively affect the achievement of the Millennium Development Goals. More frequent extreme weather events: They are linked to a potential increase in the number of deaths and injuries caused by storms and floods. In addition, flooding can be followed by outbreaks of disease, such as cholera, especially when water and sanitation services are poor, or where these have been damaged or destroyed. Storms and floods are already among the most frequent and deadly forms of natural disasters (IPCC, 2007; WHO, 2008).

Water scarcity (due to droughts) and excess water (due to more frequent and torrential rainfall): They are both expected to increase the burden of diarrhoea disease, which is spread through contaminated food and water (IPCC), 2007a; World Health Organization (WHO)/World Meteorological Organization (WMO)/ United Nations Environment Programme (UNEP), 2003). Downpours of rain can trigger sewage overflows, contaminating groundwater that is often used for crop irrigation and as a source of drinking water, causing diarrhoea diseases which are already the second leading infectious cause of childhood mortality, accounting for a total of around 1.8 million deaths worldwide each year. Heat waves can directly increase morbidity and mortality, mainly in elderly people, with Cardiovascular (heart) of respiratory disease (IPCC, 2007). Apart from heat waves, higher temperatures can increase levels of ground-level ozone and hasten the onset of the pollen season, contributing to respiratory problems, such as asthma attacks.

Table 1: Potential health effects of climate change

Manifestation of climate change	Health determinant due to climate change	Health outcome
Climate-related ecosystem changes	Temperature, humidity, rainfall effects on vector-borne (and rodent-borne) diseases	Increased vector-borne disease such as West Nile virus, equine encephalitis, Lyme disease, Rocky Mountain spotted fever, hantavirus, malaria, dengue fever, leptospirosis
	Changes in air pollution and aeroallergen levels	Increased allergies caused by pollen; increased cases of rashes and allergic reactions from toxic plants such as poison ivy, stinging nettle, and other weeds; deaths and disease cases associated with air pollution, allergies
	Emergence or spread of pathogens via climate-change-driven biodiversity loss	New cases of infectious disease
Rising temperatures and erratic rainfall patterns	Effects of extreme rainfall and sea-level rise on flooding (attributed to coastal floods, inland floods and landslides)	Fatal injuries; non-fatal injuries and mental health effects; death from drowning; increased waterborne diseases from pathogens and water contamination from sewage overflows; increased food-borne diseases
	Temperature effects on food and waterborne disease	Increased food-borne diseases, such as Salmonella poisoning, diarrhoea and gastroenteritis
	Temperature and precipitation effects on incidence and intensity of forest fires and dust storms	Death from burns and smoke inhalation; eye and respiratory illnesses due to fire-related air pollution; fatal and non-fatal injuries
	Increased average temperature	Increased strain on regional drinking water supplies; increased vulnerability to wildfires and associated air pollution
Water scarcity (drought)	Changing patterns of agricultural yield due to water shortages and increasing temperatures	Disruptions in food supply; changing patterns of crop, pest and weed species; water shortages; malnutrition food-borne and waterborne diseases; emergence of new vector-borne and zoonotic diseases
	Sea-level rise and reduced snowmelt impacts on freshwater availability	Water-related diseases in resident and displaced populations
Heat waves	Direct impact of heat waves	Premature death due to heat-related illnesses such as heat stroke, heat exhaustion and kidney stones; Cardiovascular disease /deaths
Extreme events	Destruction of health infrastructure in floods and storms	Increases in mortality and morbidity in affected areas
	Increased intensity of hurricanes due to higher sea surface temperature	Deaths by drowning; injuries; mental health impacts such as depression and post-traumatic stress disorder; increased carbon monoxide poisoning; increased gastrointestinal illnesses; population displacement/homelessness

Source From: (Campbell-Lendrum, D. H., & Woodward, R. 2007).

IV. APPROACHES TO ESTIMATING CLIMATE CHANGE IMPACT ON HEALTH

The relationship between climate change and health is complex, as climate change is not a typical 'health exposure' variable, since it does not directly display a cause to effect nexus as is sometimes seen in other determinants of health. The complexity of the relationship is compounded by the interrelationship between health and factors such as socio-economic status, disease susceptibility, cultural practices and the immediate built environment.

Methods Available for Estimating the Effects of Climate Change on Health

There are several methods available for estimating the effects of climate change on health [14]:
(i). Partial analogue studies that project future aspects of climate change.
(ii). Observing early evidence of changes in health status linked to changes in climate.
(iii). Using existing empirical knowledge and theory to conduct predictive modeling or other integrated assessment of likely future health outcomes.
A simplistic example is our natural response to heat. If climate change causes extreme heat, people may choose to stay in a cool place (e.g. an air-conditioned room), thereby reducing their exposure to heat stress. The ability of human beings to adapt to their environment adds to the uncertainty of future health impacts on climate change.

Dose-Response Approach to Projecting Climate Change Impacts

A linear dose-response approach may be used to project and value the excess disease burden caused by climate change in cases where data are scarce. This approach assumes that, for every unit change in a climate variable, there will be specific unit change in the incidence of disease. The relationships are assumed to be linear since the rate of change in disease incidence will not vary across different climate change values.

Recognising the Complexity of Systems upon which Life Depends – An Ecological Perspective

As a human-generated and worldwide process, global climate change is a qualitatively distinct and very significant addition to the spectrum of environmental health hazards encountered by humankind. Historically, environmental health concerns have focused on toxicological or microbiological risks to health from local exposures. However, the scale of environmental health problems is increasing and various larger-scale environmental hazards to human population health have begun to appear.
Appreciation of this scale and type of influence on human health entails an *ecological* perspective. This perspective recognises that the foundations of long-term good health in populations reside in the continued stability and functioning of the biosphere's life-supporting ecological and physical systems. It also brings an appreciation of the complexity of the systems upon which we depend and moves beyond a simplistic, mechanistic, model of environmental health risks to human health.

V. RESULTS AND DISCUSSION

The figures 2, 3, 4 and 5 displayed below shows the analysis of ailments frequency over a given period using the three methods of estimating and optimizing climatic change impact on health. The application was developed using the data collected from the medical hospital taken as a case study. The different ailments treated over a range of changing climatic conditions, symptoms and causative agent of such ailment over specific period of time.

Table and Figures

Ailment	No. of Patient / Frequency	Season
Malaria Fever	20	Dry
Typhoid Fever	15	Dry
Rheumatism	8	Wet
Dysentry	18	Dry
Diarrhea	5	Dry

Table 2: Frequency of Ailment

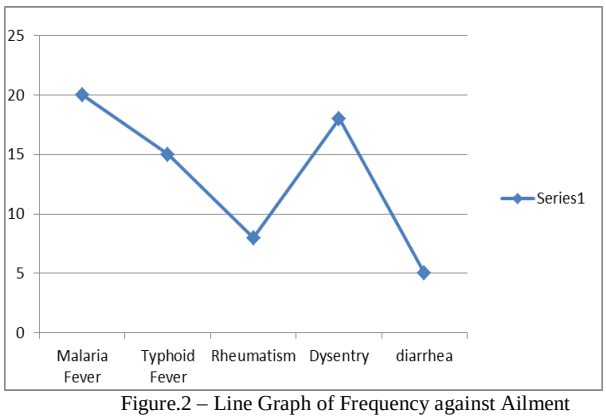


Figure.2 – Line Graph of Frequency against Ailment

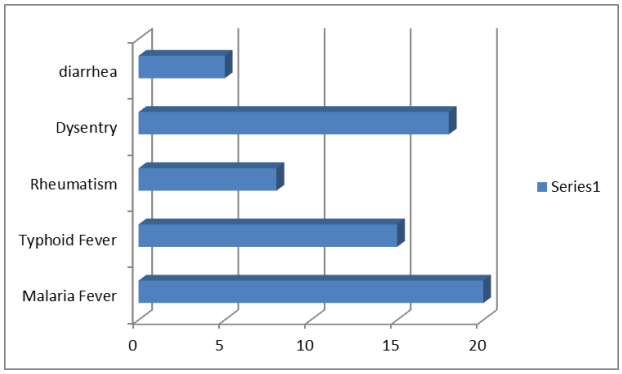


Figure.3 – Bar chart of Ailment over a period

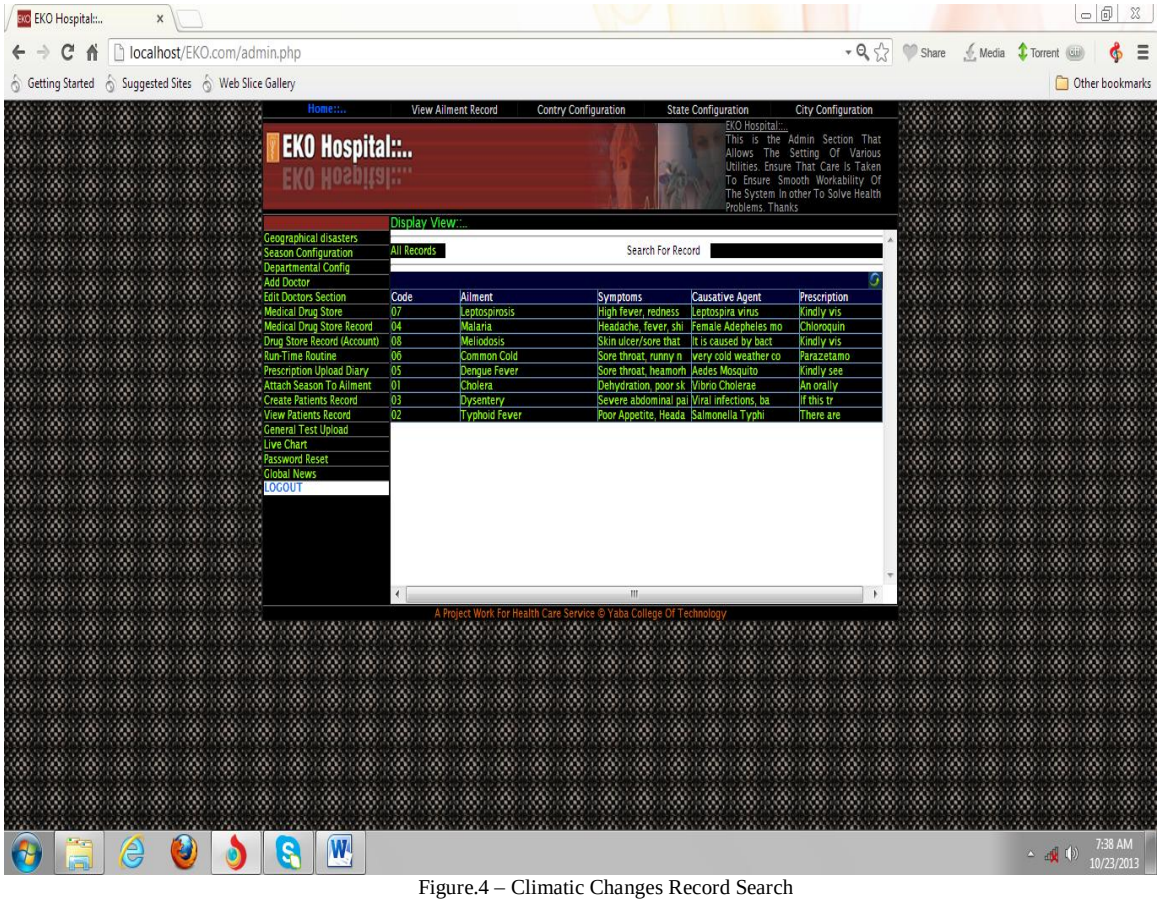


Figure.4 – Climatic Changes Record Search

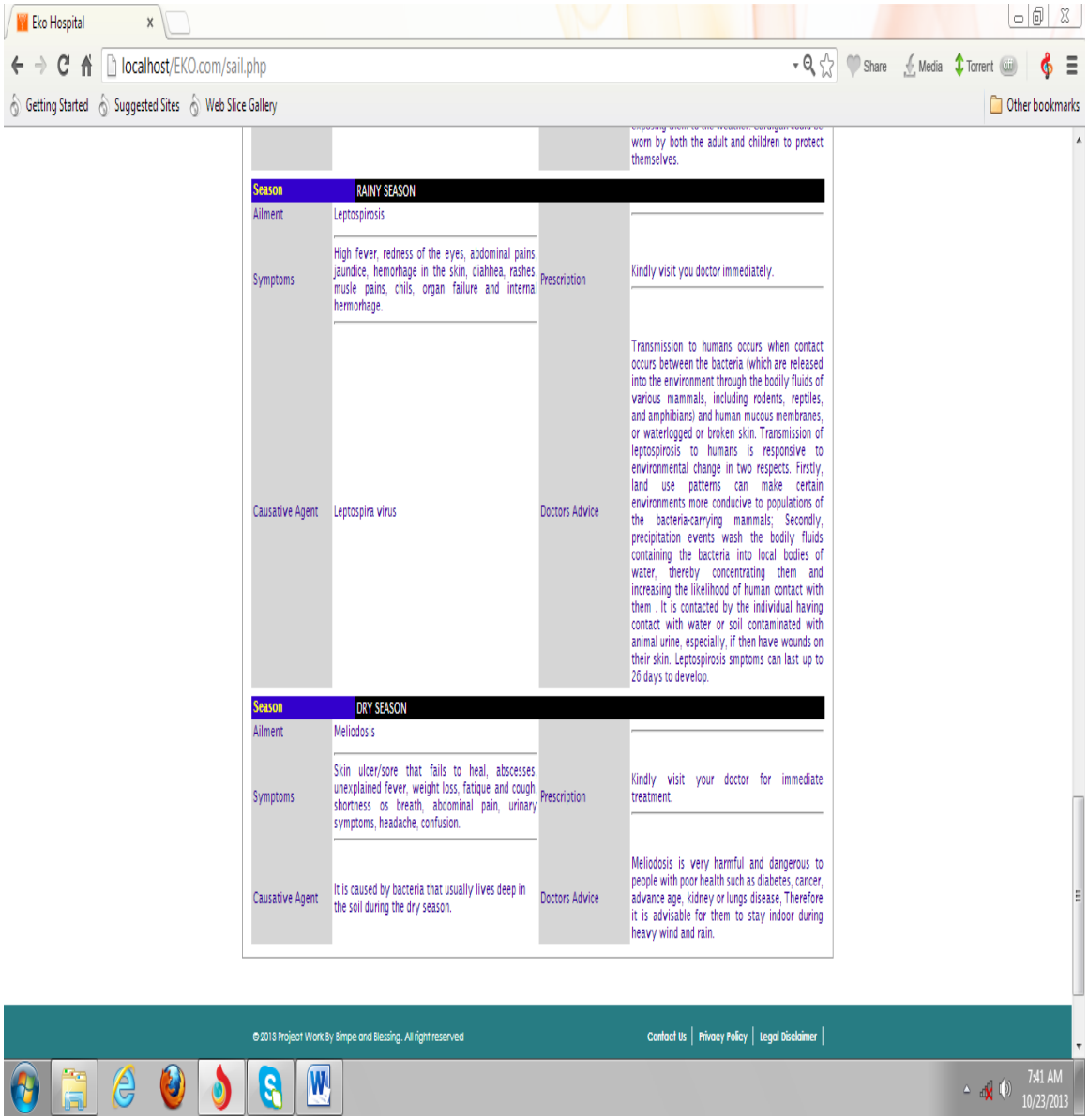


Figure.5 – Aliment, Symptom and Causative Agent

VI. CONCLUSION

According to research carried out on this study, it can be deployed and adapted for use in the healthcare sector of the society due to the fact that it helps the individual to stabilize his/her health status with respect to the changing climate. There is widespread scientific consensus that the world's climate is changing. Mounting evidence suggests current and future effects on human health, including injuries and illnesses from severe weather events, floods, and heat exposure; increases in allergic, respiratory, vector-borne, and waterborne diseases; and threats to food and water supplies. Indirect effects may include anxiety and depression and the consequences of mass migration and regional conflicts. Addressing these occurrences is a pressing challenge for public health. Although the scope and complexity of the challenge are unprecedented, the conceptual framework for responding draws on long-standing public health thinking. An effective public health response to climate change is essential to preventing injuries and illnesses, enhancing public health preparedness, and reducing risk. Science-based decision making, informed by public health ethics, will help manage uncertainty and optimize health, environmental, and economic outcomes.

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