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Possible Impacts of Climate Change on Epidemiology of Some Microbial Diseases

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Abstract

It is very obvious that the climate is changing as one now notices with increase in rainfall pattern and trend in the surface temperature of the earth. Climate change has many consequences on the spread of disease – causing micro organisms. In this paper selected microbial diseases whose epidemiology is influenced by specific aspects of the climate change problem are reviewed. The emphasis here is on water borne and vector borne diseases.

Keywords: Climate change, Epidemiology, Microbial, Disease.

1.0 Introduction

Microorganisms are ubiquitous in nature. It is documented that there are several millions of microorganisms both known and unknown but with only a small proportion being pathogenic to man.

The ability of microorganisms to survive and replicate depends on the climate (temperature, rain fall etc)- but now that considerable research activities have indicated that there are changes in the climate due to green house effects these changes would invariably affect human health as they would affect the mobility of animal hosts, vectors, replication rate and dissemination of pathogens, which are sensitive to changing temperature and rainfall.

Since the intensification of climate change its impact on human health and well being has been of great concern to researchers. The world Health Organization (WHO) estimates that increase in temperature and precipitation trends due to climate change of the past 300 years already claims over 150,000 lives annually (WHO, 2001).

Many prevalent human diseases are linked to climate change from cardiovascular mortality and respiration illness due to heat waves, to altered transmission of infectious disease, malaria, malnutrition from crop failure and water borne, food borne and vector borne diseases (Patz et al., 2006). A study by Constantin de Magy et al., (2008), suggests that cholera out breaks in the West African region could be the effects of climate change on human health.Another health consequence of climate change is meningitis especially in the Sahel countries (including Nigeria) with the reduction in rainfall, the concentration of Aerosols (dust particles) in the air increases during wind blow (West African Health Organization, 2009).

Climate plays a major role in the spread of malaria as the spread of this disease relies upon sufficient number of Anopheline mosquitoes and a large enough parasite pool amongst humans and animals. The behaviours, development and population of mosquitoes are strongly influenced by climatic factors like temperature, humidity and rainfall (Zhou et al., 2004; Craig et al., 2004). The relationship between these climate factors as they affect mosquitoes however, are highly complex and varies from region to region and between the different anopheline species (Tren, 2002).

This paper reviews the potential health impacts of two likely changes in climate, an increase in the frequency of heavy rainfall events along with associated floods and increase in temperature, and the discussion will be further restricted to microbial diseases.

2.0 Climate Change

Climate is defined as the average weather condition

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of a place over several decades. There are certain indicators that one can use to predict climate like temperature, rainfall and precipitation. A change in the trend of these indicators is what we refer to as climate change e.g. rise in temperature or change in rainfall pattern.

Climate change is as a result of predictions based on scenarios that use gas emission from potential resource use patterns, technological innovations and demographics. Its predictions are from the results from modeling experiments based on these emission scenarios, depending on the assumptions quantified by each scenario. There can also be sources of uncertainty in prediction due to inability to fully predict human resource use and in complete understanding of climate processes.

These green house gases have led to warming up of the world and have placed human health at risk. The resurgence of vector borne diseases and zoonoses is cited as an effect of climate change as it will help increase animal reservoir and the numbers of insect vectors; will extend the transmission cycle and will encourage the arrival of new insects or reservoirs in some regions because of the new climate conditions

3.0 Effects of Climate Change on Pathogen and Vector

Microbial communities are likely to shift with climate change. Research has proved that elevated CO_2, temperature and rainfall patterns are very important factors in driving microbial communities and insect vectors. Microbes like any other living thing will adapt or survive more where climatic conditions are more favorable for them. Since changes in the rate of replication and dissemination of pathogen and vector are sensitive to changing temperature and rainfall, we will now discuss these parameters and how they can affect the mobility of microbial and vector communities.

3.1 Temperature

This is a dominant climate factor. It could be high or low. In many cases, temperature increases are predicted to lead to geographical expansion of pathogens and vector distribution, thereby bringing in contact or providing pathogens with more potential host. It also helps in providing new opportunities for pathogens. Hybridization increase in human movement can also act synergistically with temperature changes. For example rust fungi (puccinia graminis) a pathogen in the soil community is limited by climate requirements. Its surviving is increased during very cold temperatures. In this case of Phytophthora infestans, they normally experience increase multiple mating types, allowing sexual reproduction during very cold temperatures. Dothistroma septosporum that causes needle blight in North America moves north with increasing temperature. Increase in temperature increases the metabolic rate of blood sucking vectors like mosquitoes. For microbial diseases of corals it was also noticed that when infected corals are maintained at a winter temperature at 16^{o}C, it would cause rapid death of the intracellular bacterial (Israely et al., 2001).

3.2 Rainfall

This is also an important factor in climate change. It also has its own effect on microorganism. When it is too heavy it could be detrimental, when there is none at all it could lead to their death and dispersal. Changes in rainfall pattern can directly affect vectors and pathogens such as their reproduction rate, the biting frequency of the vector and the amount of time the host is exposed to the vector. An example of pathogen range shift that is associated with climate change due to change in rainfall is the wheat stripe rust which is spreading in South Africa. Flooding as a result of heavy down pour can shift the geographical distribution of vectors.

Pathogen movement is difficult to study at large scales even in a relatively homogenous environment with changing climate. For example there is little evidence of direct effect of Co_2 or UVB and that of precipitation effects on insect herbitat and as such sufficient general conclusions cannot be drawn (Bale et al., 2002).

3.3 Effects of Climate Change on Virulence Aggressiveness of Pathogen

Virulence of a pathogen simply means the ability of that pathogen to invade a host cell and cause disease. For it to succeed in causing disease, it must be able

to multiply within the host cell, by –passing the defense mechanism of that host. Now, the evolution rate of pathogens are determined by a number of generation of pathogen, reproduction per time interval along with other factors which could be as result of climate change. Temperature, rainfall determines the rate of reproduction of many pathogens. For example, spore germination of the rust fungus Puccinia substriata increases with increasing temperature while the root rot pathogen of plants Monosporascus cannonballus reproduces more quickly at higher temperature. Seasons with higher temperatures will certainly encourage pathogen evolution. Large pathogen population may also encourage a more rapid pathogen evolution, so increased over summering or over wintering rates will also contribute. The relationship between increased sea water temperature and infectious diseases, could also be attributed to increase in the virulence of these pathogens due to climate change. The method of reproduction of most pathogens whether sexually or asexually can also be determined by climate change (Giarreth et al., 2002). In some instances very cold temperatures may favour sexual propagules, thereby increasing the evolutionary potential of a population under climate change.Some pathogens may potentially be unable to migrate or adapt rapidly as environmental conditions change while most pathogens will have the advantages because of their shorter generation time. This could be due to their ability to move readily by wind dispersal especially during drought. Certain strains of cholera have been found sensitive to some environmental fluctuations (Koelle et al., 2005).

4.0 Possible Effects of Climate Change on Some Selected Diseases

Microbial diseases are those diseases caused by microorganisms. These are numerous. But in this work, these will be reviewed under two major headings: - water borne and vector bore diseases. This work will look at these diseases under two major climate change parameters, which are increase in rainfall and increase in temperature.

4.1 Waterborne Diseases

These are those disea-ses that are transmitted through water. Water can get contaminated by coming in contact with sewage. This can cause major disease burden and mortality globally (Pruss and Havelaar, 2007). Its consequences are felt more by poor societies and especially in children under 5 years. This disease burden is associated more with viruses, parasites and bacteria (Hunter, 1998). Some of these diseases can be contacted either by drinking or by coming in contact with recreational water (Hunter, 1997). The rate of spread differs from one country to another. Some are widely spread while some are locally spread in a particular area. For example, diseases like cryptosporidiosis and campylobacteriosis are widely spread while diseases like vibro cholera, Hepatitis E virus and shistosomiasis are restricted to some tropical countries. Some microbial pathogens linked to drinking water or recreational water contact have been enumerated (Hunter, 1997).

4.1.1 Climate Change Impacts on the Spread of Waterborne Diseases

There is no doubt that climate change will play a major role in the spread of waterborne diseases as discussed below.

- **Rainfall Trends**

Previous researchers have noted that waterborne diseases outbreak has always been preceded by heavy rainfall (Joseph et al., 1991; Bridgman et al., 1995; Miettinen et al., 2001). An example of waterborne outbreak as a result of heavy rainfall and associated flooding was the Walkerton outbreak of Escherichia coli in Canada which affected over 1000 people of whom 65 were admitted to hospital and six died (Anon, 2000). There are numerous ways heavy rainfall can lead to outbreak of waterborne diseases.

- **Change in the direction of flow**

Heavy down pour can lead to change in the direction of flow of water and this can cause water to run across surfaces that normally did not occur. In so doing water could come in contact with sewage. This can lead to increase in the amount of feacally polluted waters especially surface waters. It can also cause water to leak into the ground thereby contaminating under ground waters.An example is the outbreak of cryptosporidiosis associated with underground water (Bridgman et al., 1995). Heavy rainfall has also been associated with increase in the turbidity of

surface waters.This could be as a result of increase in bloom formation (Lechevallier et al., 1991) and as such can lead to additional stress on inadequate water treatment systems.

Researchers have also proved that there is a relationship between rainfall and the presence of various organisms in water especially enteric pathogens in water (Miossec et al., 2000). Some rivers have been associated with an increase on detecting Giardia Cryptosporidium (Atherbolt et al. 1998). Heavy rainfall also leads to high counts of indicator bacteria as well as potential pathogens, which could be as a result of storm water runoff into surface water sources (Doran and Linn 1979; O'shea and Field, 1992). It can also lead to high counts of indicator bacteria in rivers (Tunniccliff and Brickler, 1984) and marine water have not been known to be associated with disease (Edberg et al., 1986; Zmirou et al., 1987; Hellard et al., 2001). Heavy rainfall can also give rise to flooding, which could lead to enormous damage and financial loss (Malilay, 1997). It is one of the commonest natural disasters and one of its greatest threat to man is drowning and can as well render man homeless. In the developed world its threat to human health is however scant because authorities there have provided avenues to have these events under control (Bissell, 1983; Aavitsland et al., 1996; Malilay, 1997; Greenough et al., 2001). Some examples of outbreaks associated with flooding is the Nicaragua following Hurricane Mitch acute diarrhoea and acute respiratory disease. Some diseases like malaria, Hepatitis E and diarrhoeal disease have also been associated with flood in Khartoom (Homeida et al., 1998; Shears, 1988).

- **Changes in Temperature**

Rise in water temperature encourages the bloom of some planktonic species.This increase in bloom formation is as a result of increase in nutrient concentration (Lechevallier et al., 1991). These planktonic species are hazardous to human health and can cause diseases either from drinking or by coming incontact with it for recreational purposes. Examples of some planktonic species that can cause disease to man include:

- **Cyanobacteria**(blue – green algae) that have been associated with some clinical syndromes such as dermatitis, respiratory problems and hepatitis (Hunter, 1998). Its clinical syndrome starts after drinking water that contains its toxins or when used for recreational purposes.
- **Dinoflagellates:** this has been associated with some neurotoxic, diarrhetic and amenesic shell fish poisonings (Hungerford, 2007) although they are not directly classified as waterborne disease.
- **Pfiesteria piscicida:** This can be classified as dinoflagellates although it has been associated recently with a syndrome known as 'estuary associ-ated syndrome'. This leads to acute respiratory and eye irritation and had also been associated with deficiencies in learning memory and acute confessional states in people who have come in contact with contaminated water and aerosols. According to Maier and Dandy (1997), Jacoby et al. (2000) and Saker and Griffthos (2001) high temperatures encourage the growth of algae and bloom formation. It is now obvious that V. cholera, which is the causative agent of cholera, survives in marine waters in a viable but non – cultural form that might seem to be associated with algae and plankton (Isam et al., 1990; Colwell, 1996). In such case anyone who drinks from such water will be subjected to high risk. High water temperature has also been associated with prolonged survival of pathogens in the environment. Although this has not been proved in most cases, while on the contrary high water temperature does not support the survival of enteric pathogen. This has been proved in the case of campylobacter (Bushwell et al., 1998; Thomas et al., 1999), entero herorrhagic E. coli (Wang and Doyle, 1998; Rice and Johnson, 2000), V. cholera and enteroviruses (Hurst et al., 1989.).

4.2 Vector Borne Diseases

These are diseases that are spread or transmitted through insect vectors. These insects (mosquitoes, black flies) play a major role in the transmission of infection from one person to another or from animal

hosts to man. There are numerous parasitic, bacterial, viral diseases that can be transmitted through insects (Cook, 1996). Vector borne infections are among the major microbial causes of diseases and can lead to a high mortality and morbidity in the world today. Malaria alone causes some one million deaths and 273 million cases world wide each year (Rogers and Randolf, 2000).

4.2.1 Climate Change and Its Impact on the Spread of Vector Borne Diseases

The two major factors that determine the geographical distribution of vector borne disease is the geographical distribution of the host (where one resides) and the distribution of the vector. We will discuss the effect of climate change on vector borne diseases under these headings:

- **Rainfall effects**

There are numerous ways rainfall can impact on the risk of spread of vector borne diseases. Some possible mechanisms includes:

o Increased rainfall can lead to increased breeding sites for vectors. This could be as a result of increased water surface collections. During heavy downpour, waters are collected in pot holes which became stagnant thereby encouraging insect vectors to breed especially mosquitoes. During increased rainfall there is usually an increase in vegetation which invariably create room for vectors to breed. Increased vegetation can also allow expansion in population of vertebrate hosts.

o Low rainfall can also increase breeding sites by slowing river flow. This has been shown to be associated with epidemics of St. Louis Encephalitis (SLE) when the vector, clulex pipiens, starts to breed in urban drain systems (Mitchell et al., 1980).

o Flooding as a result of heavy rainfall can eliminate habitat of both vertebrate hosts and vectors. It can also change the geographical location of both vectors and vertebrate host and in so doing may force vertebrate hosts into closer contact with humans.

Generally, changes in rainfall pattern have direct effects on both vectors and pathogens such as changes in their reproduction rate, the biting frequency of the vectors and the amount of time the host is exposed to these vectors.

Less rainfall or no rainfall at all can give rise to drought. In some countries for example Nigeria, the annual rainfall total has decreased drastically at most northern locations such as Maiduguri in the North – east of the Country (Chineke et al., 2010). During drought, dust particles tend to increase the amount of microorganisms in aerosols in the atmosphere due to wind. Due to the high suspension of micro-organisms in the atmosphere, there is usually a high risk of upper respiratory tract infections due to direct contact of organisms and humans through inhalation. Some diseases have been noted to be more predominant during this period like meningitis which is usually common in the Sahel countries (including Nigeria).

- **Temperature Effects**

Changes in temperature can affect both the distribution of vector and the effectiveness of pathogen transmission. Changes in temperature can affect the risk of transmission of vector borne diseases in the following waays:

o Changes in temperature can determine the rate of survival of vector. Some vectors can survive more in high temperature while some will prefer low temperature depending on the type of vector.

o Changes in feeding pattern. High temperature increases the metabolic rate of vectors thereby increasing their nutritional requirements like blood sucking vectors such as mosquitoes.

o Changes in temperature can also determine the rate of susceptibility of vectors to pathogens, as increase in temperature leads to geographical expansion of pathogens and vector distribution thereby bringing pathogens in close contact with more potential hosts.

o Changes in temperature also change the pathogens incubation period. This is because increase in temperature governs the rate of reproduction of pathogens since most pathogens tends to have shorter generation time.

Changes in temperature have also been noted to determine the changes in seasonality of vector activities and pathogen transmission. For example diseases like St Louis. Encephalitis (SLE) have been noted to follow periods of hot weather where temperature exceeds 30°C for seven consecutive days (Monath and Tsai, 1987).

5.0 Possible Future Impacts of Climate Change on Health and Possible Remedies

It is true that the climate is changing but one cannot decipher what the future climate holds for us. But judging from what we are seeing now one would say that its impact will be felt more by the under developed or developing countries unlike the already developed countries.

- Lack of safe water supply in these countries; unlike in the developed countries where there are high standard water treatment and supplies. So in such case, one will experience high risk of diseases associated with water. This can also push people in the underdeveloped or developing countries to engage in private water supplies. In this case assuming heavy down pour becomes more common then the safety of these private water supplies becomes questionable.
- Poor drainage system in under developed countries will certainly encourage flooding assuming heavy rainfall also becomes common or more frequent. Apart from loss of lives and properties, it can contaminate surface waters by carrying sewage along with it there by rendering water unfit and unsafe for both drinking and recreational purposes.
- Poor environmental sanitation in these countries will also create conducive environment for insect vectors to breed due to poor weed and vegetation control. Indiscriminate waste disposal, will certainly encourage the risk of vector borne diseases especially in countries like Africa where diseases like malaria are endemic. Increase in temperature, this will certainly encourage algae bloom which will in turn lead to increase in the risk of contacting diseases from recreational use of water.

5.1 Ways To Rectify These Problems.

- Provision of safe water supply systems.
- Provision or construction of good drainage system with strong materials.
- Provision of good medical and public health facilities.
- Good control of pest and vector of public health importance.
- Provision of good environmental sanitation.
- Good control of environmental pollution like vehicular emission, gas flaring etc.
- Distribution of insecticide treated nets especially in areas where some of these vector borne diseases are endemic.
- Improvement in the primary health structures to be responsive to emergencies associated with climate change.

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