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# Climate Change and the Risk of Emerging and Re-Emerging Diseases

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### Abstract

The emergence and re-emergence of diseases can be as a result of any of pathogen, host or environmental factors. Within the environment, climate change which is an extrinsic factor, is a major determinant. Viral, bacterial, fungal and parasitic infections have all emerged and re-emerged at one point or the other. Vector-borne diseases are more prone to the impact of climate change. This is evidenced by the spate at which malaria has decreased dramatically in the last decade or so in areas where climate change has significant effects. There is now evidence that in some areas of the world, example Horn of Africa, warm El Nino Southern Oscillations (ENSO), which are observed in the South Pacific Ocean, are associated with higher risk of emergence of Rift Valley fever, cholera and malaria and during cold La Nina events, dengue fever, chikungunya and yellow fever. This has been observed for these and other diseases in other parts of the world. Climate change can be reduced by mitigation, adaptation, geoengineering and knowledge-base-expansion. It is also essential that broad based prevention strategies, as well as new and improved countermeasures (that is, surveillance tools, diagnostics, therapeutics and vaccines), be continually tested, refined and upgraded to curb the emergence and re-emergence of diseases especially those mostly impacted by climate change.

### Keywords

Climate Change, Risk, Emerging and Re-Emerging Diseases

## 1. Introduction

The rapidly changing environment matters a lot to human health. And it is no news that the climate which is integral to the environment is changing too. In fact, if you feel heat, smell smoke, hear a fire alarm, and see flames then you have independent confirmation from four senses that there's a fire. This is the same with climate change. The evidence that climate is changing comes from more than a dozen independent measurements. Suffice to add that not only the climate changes, infective agents do too. The microbial world is generally a complex one. It is very dynamic and constantly evolving. Microorganisms reproduce rapidly, mutate frequently, cross the species barrier between hosts and humans and adapt with relative ease to new found environments. Because of these traits, infectious agents are able to alter their epidemiology, their virulence, and even their susceptibility to antibiotics. These almost non-modifiable threats posed by both climate change and infectious agents call for proactive and pragmatic approaches towards their management.

## 2. Climate Change

Climate change is a change in the statistical distribution of weather patterns when that change lasts for an extended period of time (i.e., decades to millions of years). Climate change may refer to a change in average weather conditions, or in the time variation of weather within the context of longer-term average conditions. This concept which is otherwise referred to as global warming had to do with the gradual increase in the temperature of earth's atmosphere and oceans mainly as a result of increase in the concentration of greenhouse gases (GHG) in the atmosphere and this increase is mostly due to anthropogenic activities [1]. Anthropogenic climate change is caused by human activity, as opposed to changes in climate that may have resulted as part of Earth's natural processes. Climate change could be caused by other factors such as biotic processes, variations in solar radiation received by Earth, plate tectonics, and volcanic eruptions. But to be more specific, global warming refers to surface temperature increases while climate change includes global warming and everything else that increasing greenhouse gas levels affect [2]. Water vapor and less abundant atmospheric components, such as carbon dioxide ($CO_2$) (390 μmolmol$^{-1}$), methane ($CH_4$) (1.7 μmolmol$^{-1}$), nitrous oxide ($N_2O$) (0.3 μmolmol$^{-1}$) etc are known as greenhouse gases, because of their long atmospheric lives and their relatively high thermal absorption capacities.

The most general definition of climate change is a change in the statistical properties (principally its mean and spread)[3] of the climate system when considered over long periods of time, regardless of cause [4]. Accordingly, fluctuations over periods shorter than a few decades, such as El Nino, do not necessarily represent climate change.

In the context of climate variation, anthropogenic factors are human activities which affect the climate. The scientific consensus on climate change is "that climate is changing and that these changes are in large part caused by human activities [5]," and it "is largely irreversible [6]."

According to the United States National Research Council, Advancing the Science of Climate Change, "science has made enormous inroads in understanding climate change and its causes, and is beginning to help develop a strong understanding of current and potential impacts that will affect people today and in coming decades. This understanding is crucial because it allows decision makers to place climate change in the context of other large challenges facing the world. There are still some uncertainties, and there always will be in understanding a complex system like Earth's climate. Nevertheless, there is a strong, credible body of evidence, based on multiple lines of research, documenting that climate is changing and that these changes are in large part caused by human activities. While much remains to be learned, the core phenomenon, scientific questions, and hypotheses have been examined thoroughly and have stood firm in the face of serious scientific debate and careful evaluation of alternative explanations." Of most concern in these anthropogenic factors is the increase in $CO_2$ levels. This is due to emissions from fossil fuel combustion, followed by aerosols (particulate matter in the atmosphere), and the $CO_2$ released by cement manufacture [7]. Other factors, including land use, ozone depletion, animal husbandry (ruminant animals such as cattle produce methane [8], as do termites), and deforestation, are also of concern in the roles they play - both separately and in conjunction with other factors-in affecting climate, microclimate, and measures of climate variables [9].

It has been reported that besides water vapor, the most important greenhouse gas is $CO_2$, but $CH_4$ and $N_2O$ are also important contributors to global warming [10]. However, it is important to note that greenhouse gases in the atmosphere play an important role for life on earth. It has been calculated that the average temperature of earth, which is 15°C nowadays, would be −15°C or −18°C if the green house gases were not present, which would severely limit life on earth [10].

## 3. Emerging and Re-Emerging Diseases

Infectious diseases have for centuries ranked with wars and famine as major challenges to human progress and survival. They remain among the leading causes of death and disability worldwide. Against a constant background of established infections, epidemics of new and old infectious diseases periodically emerge and re-emerge, greatly magnifying the global burden of infections.

By definition, emerging diseases can be seen as "diseases that have newly appeared in a population or have existed previously but are rapidly increasing in incidence or geographic range" [11]. Emerging diseases have shaped the course of human history and have caused incalculable misery and death. In 1981, a new disease - acquired immune deficiency syndrome (AIDS) - was first recognized. As a global killer, AIDS now threatens to surpass the Black Death of the fourteenth century and the 1918–1920 influenza pandemic, each of which killed at least 50 million people [12]. On the other hand, re-emerging or resurging infectious diseases are those that existed in the past but are now rapidly increasing either in incidence or in geographical or human host range. Re-emergence is caused by some of the factors that cause newly emerging infectious diseases, such as microbial evolutionary vigour, zoonotic encounters and environmental encroachment. Re-emergence or at least cyclical resurgences of some diseases may also be climate-related — for example, the El Nino Southern Oscillation (ENSO) phenomenon is associated with resurgences of cholera and malaria [13]. Of the 'newly emerging' and 're-emerging/resurging' diseases that have followed the appearance of AIDS, some have been minor curiosities, such as the 2003 cases of monkey pox in the United States [14], whereas others, such as severe acute respiratory syndrome (SARS), which emerged in the same year [15], have had a worldwide impact. The 2001 anthrax bioterrorist attack in the United States [16] falls into a third category: 'deliberately emerging' diseases. Emerging and re-emerging infectious diseases can be expected to remain a considerable challenge for the foreseeable future.

## 4. Relationship Between Climate Change and Diseases

The links between climate change and diseases are complex. Climate change as an environmental factor is among many other determinants, such as social and political factors that act on transmissibility of diseases. Many common infectious diseases are known to be affected by climate variation. But those transmitted by insects are particularly sensitive. One example, which illustrates this kind of complexity is malaria, for which the number of cases has dramatically decreased during the past decades [17]. This parasitic infection kills around 429,000 people each year (more than 80 percent of whom are children under five), and although that number is on the decline, there are fears that in the future, climate change could help malaria spread. This decrease was observed due to large financial investments in the fight to eliminate the disease, although climate change undoubtedly hinders the progress towards elimination.

The incidence of infectious disease has been dramatically reduced over the past century by increasingly sophisticated vaccines. But evidence suggests that climate change could again, potentially lead to a resurgence of some of the deadliest illnesses on earth. Climate in the future might become more suitable for malaria transmission in the tropical highland regions, as being modelled [18]. Malaria is transmitted to humans by mosquitoes of the genus Anopheles, which are highly sensitive to climatic variations, generally requiring moist conditions, and a temperature of around 25-28 degrees centigrade to breed. Scientists suspect that rising global temperatures could cause the range of Anopheles mosquitoes to expand, and thereby increase the spread of malaria to humans. One of the places most at risk could be Africa. The continent is already the world's malaria hotspot, with 92 percent of the world's malaria deaths occurring there, but a growing number of scientific studies are suggesting that climate change could make malaria matters even worse in Africa.

Malaria is not the only mosquito-borne disease that risks being exacerbated by a changing climate. Studies have also found that climate variability could also affect the risk of dengue fever, and there are concerns that the same could be true for yellow fever, encephalitis, hantavirus and even ebola. There are even signs that climate change could already be altering the distribution of some of these diseases. Recent studies have found that some mosquito-borne diseases, including malaria, dengue fever and yellow fever, as well as tick-borne diseases like Lyme disease and tick-borne encephalitis, have begun to spread to higher latitudes, possibly due to increased temperatures. The spread of insect-borne pathogens is serious enough, but it is not the only way that climate change could impact human diseases.

Increased precipitation, another likely result of climate change, is believed to increase the spread of waterborne infections, which can cause deadly diarrheal illness and flourish in the wake of heavy rainfalls. And other infectious diseases, such as salmonellosis, cholera and giardiasis, may show increased outbreaks due to flooding and elevated temperature. Scientists are also concerned that the melting of permafrost soils in polar regions due to climate change could release ancient viruses and bacteria that may be capable of coming back to life.

Again, there are evidences on how El Nino Southern Oscillations (ENSO) in the Southern Pacific may affect the climate in many parts of the world and, as a consequence, also affect communicable diseases. A recent report [19] have highlighted the risk that climate change may have an influence in increasing intensity and frequency of the El Nino/La Nina phenomenon. The Pacific Ocean is the largest mass of water in the world, so any variations in its temperature have a repercussion on climate in many points of the planet. For example, El Nino has been associated with heavy rainfalls in the horn of Africa over several years and with anomalies in vegetation (wetter than usual) observed from satellites. A strong correlation between the El Nino effects and outbreaks of Rift Valley fever (RVF) in the Horn of Africa have been shown [20]. RVF is a very severe, arboviral, mosquito transmitted disease affecting both cattle and humans. In the Horn of Africa, excessive humidity observed from remote sensing, alongside the El Nino phenomenon, is linked to higher probabilities of RVF epidemics.

At the end of 2015, the world experienced a strong El Nino phenomenon. If these events happen more frequently and intensely due to climate change, there is a risk of a greater number of outbreaks of emerging or re-emerging infectious diseases. In 2007, El Nino has been found associated with an increase in probability of RVF, cholera and malaria [21] in the Horn of Africa. In other parts of the world such as Bangladesh, temperature rises in the waters of the Gulf of Bengal are tied to re-emerging cholera; for similar reasons, the risk of cholera in Peru has also been increasing. Reversely, El Nino causes drought and heat waves in North-East Brazil and Southeast Asia increasing risks of dengue fever [21].

La Nina is the reverse climatic phenomenon to El Nino. Surprisingly, since it is known as a "cold oscillation", La Nina will probably also increase in intensity and frequency as a result of climate change [19]. This climatic oscillation is also associated with the emergence of epidemics that have been reported in the recent past.

In May 2004, heatwave and droughts were observed in the coastal areas of Kenya, towards Lamu and Mombasa, two large coastal cities. That period was also the beginning of a large outbreak of chikungunya in these two cities (with reported attack rates of 75%) prior to its spread to the Indian Ocean [22]. Entomologists have explained how and why droughts can be associated with increases in Aedes-borne diseases, such as chikungunya, as well as dengue, Zika and yellow fever [23]. During droughts, due to water scarcity, people are prone to store larger amount of water, outside, in the shadow of their house, for longer time periods, providing shelters to mosquitos' eggs and larvae.

Vector-bone diseases are not the only maladies linked to El Nino and/or La Nina.

Recent studies show that twentieth century pandemics, such as influenza pandemics, were associated with the La Nina phenomenon [24]. This link has been previously studied through seasonal influenza epidemics, and a statistical correlation was found with La Nina, both in the USA and Europe [25]. There is indeed a strong synchronization of seasonal influenza epidemics between Europe and the USA as data collected over several decades demonstrates less than half a week in time difference in epidemic peaks between France and the USA [26]. In addition, there is a correlation between the size of the seasonal influenza epidemics between France and the USA. This intercontinental synchronism points to the possibility that a climatic force could be a factor. Indeed, a positive correlation was found between the size and severity (in terms of mortality) of influenza epidemics in Europe and the USA and La Nina cold oscillations in the South Pacific Ocean [26].

## 5. Curbing the Challenge of Climate Change and Disease Emergence and Re-Emergence

Climate will continue to change and diseases will continue to emerge and re-emerge, leading to unpredictable epidemics and difficult challenges to public health. To avoid the worst effects of climate change, there is need to dramatically reduce global carbon emissions. But the significant and unavoidable consequences of carbon emissions such as increasing temperatures, shifting precipitaton patterns, ocean acidification, sea level rise and the increasing intensity and frequency of extreme weather events must also be prepared for. In the same light, surveillance and response remain the key elements in controlling diseases be they naturally occurring or deliberately engineered. But these depend on rapid clinical diagnosis and detection and containment in populations and in the environment.

Climate change can be reduced by at least four approaches, viz; mitigation-efforts to reduce greenhouse gas emissions; adaptation-increasing society's capacity to cope with changes in climate; geoengineering or climate engineering-additional, deliberate manipulation of the earth system that is intended to counteract at least some of the impacts of greenhouse gas emissions; and lastly knowledge-base expansion-efforts to learn and understand more about the climate system, which can help support proactive management of consequences.

Mitigation: approaches to reducing emissions fall into several categories. These include regulation; research, development, and deployment of new technologies; conservation; efforts to increase public awareness; positive incentives to encourage choices that lower emissions; and adding a price to greenhouse gas emissions, which creates incentives to reduce emissions broadly.

Adaptation: this basically involves planning for climate impacts, building resilience to those impacts, and improving society's capacity to respond and recover. This can help reduce damages and disruptions associated with climate change. Adaptation policy can include regulation to decrease vulnerability (e.g., through land-use planning and building codes); response planning; disaster recovery; impact assessment for critical systems and resources (e.g., water, health, biological systems, agriculture, and infrastructure); observations and monitoring; and efforts to minimize compounding stresses such as traditional air pollution, habitat loss and degradation, invasive species, and nitrogen deposition.

Geoengineering: this refers to deliberate, often global-scale, manipulations of the climate system. Two categories of geoengineering are most prevalent within scientific and policy discussions: solar radiation management (offsetting human-caused warming due to greenhouse gas emissions by reflecting incoming sunlight back to space) and carbon removal and sequestration (extracting carbon dioxide from the air and storing it deep in the ground or ocean).

Knowledge-base expansion: it is worthy of note that research, observations, scientific assessments, and technology development can help reveal risks and opportunities associated with the climate system and support decision-making with respect to the curbing of risk posed by climate change. Expanding the knowledge base allows policy makers to understand, select, and refine specific risk management strategies and to thereby increase the effectiveness of risk management efforts. Knowledge-base expansion can, in some cases, also reveal entirely new opportunities for protecting the climate system or reducing the risks of climate change impacts.

Just like climate change, underlying disease emergence and re-emergence are evolutionary conflicts between rapidly evolving and adapting disease agents and their slowly evolving hosts. These are fought out in the context of accelerating environmental and human behavioural alterations that provide new ecological niches into which evolving microbes can readily fit. It is essential that broad based prevention strategies, as well as new and improved countermeasures (that is, surveillance tools, diagnostics, therapeutics and vaccines), be continually tested, refined and upgraded, requiring a strengthened relationship between public health and basic and clinical sciences.

"The future of microbes and mankind will probably unfold as episodes of a suspense thriller that could be entitled Our Wits Versus Their Genes" [27]. This was how Joshua Lederberg summarized the challenge between disease agents and man, but humans can go a step better than their great rivals with vision and sustained commitment to climate management and disease prevention.

## 6. Conclusion

For over 50 years, there has been an increase in outbreaks of emerging and re-emerging infectious diseases, and climate change is probably one of the key drivers of this increase. Vector-borne diseases are among those enduring the greatest impact by climate conditions and global warming but airborne transmitted diseases may also be affected. It is therefore paramount to develop strategies that can drastically result in discountenance of infectious diseases especially those associated with change in climatic conditions.

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