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GLOBAL CLIMATE CHANGE AND EMERGING INFECTIOUS DISEASES

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Abstract

In addition to multiple human, biological, and ecological determinants, global warming has led to the emergence and re-emergence of infectious diseases. An upward trend in global temperatures and an estimated rise of 2.0 degrees C by the year 2100, can affect the dissemination of many serious infectious diseases. The incidence of mosquito-borne diseases, including malaria, dengue, and viral encephalitis, are among those diseases most sensitive to climate. Even an increase in sea surface temperature is leading to a higher incidence of water-borne infectious and toxin-related illnesses, such as cholera. This paper attempts to analyze and understand the linkages between climatological and ecological change as determinants of disease emergence, and how to optimize preventive strategies.

Keywords: Biodiversity, climate change, global warming, infectious disease.

"As human-caused biodiversity loss and climate disruption gain ground, we need to keep our sights clear and understand that the measure of a threat is not a matter of whether it is made on purpose, but of how much loss it may cause. It's an ancient habit to go after those we perceive to be evil because they intended to do harm. It's harder, but more effective, to "go after," meaning to more effectively educate and socialize, those vastly larger numbers of our fellow humans who are not evil, but whose behavior may, in fact, be far more destructive in the long run."

-Ed Ayres, World Watch, 2001

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NTRODUCTION

The world's leading scientists agree that the planet is warming and that human activity, such as the burning of fossil fuels, clearing of forests, etc**.** are a big part of the cause. In a 2007 report, the Intergovernmental Panel on Climate Change (IPCC), an international group of scientists charged with reviewing, validating and summarizing the latest research concluded that the warming of the climate system is unequivocal. They stated that it is 90 percent certain that human-generated greenhouse gases account for most of the warming in the past 50 years.

The World Health organization estimated nearly 12.6 million deaths each year due to unhealthy environments. In fact, environmental risk factors, such as air, water and soil pollution, chemical exposures, climate change, and ultraviolet radiation, contribute to various diseases and injuries. In fact, many published scientific reports have documented the actually observed impacts of a warming planet including dramatic melting of the Arctic ice cap, shifting wildlife habitats, increased evidence of wildfires, volcanic eruptions, heat waves, and more intense storms, cyclones, and hurricanes. This warming trend poses serious risks to the economy, health as well as the environment. (Environmental Protection Agency 2001) This paper attempts to analyze and understand the linkages between climatological and ecological change as determinants of disease emergence throughout the world, and how to opt for preventive strategies and mechanisms.

Ecological disruption is a major force behind the spread of established and emerging diseases. As mankind alters the environment he is therefore literally sowing the seeds for his own destruction. The increased ferocity of disease we are now facing is a direct result of our ecological impact on the planet. The World Health Organization (WHO) estimates that this ecological impact is the root cause of new and emerging infectious diseases. When environments change quickly, and ecosystems are transfigured or eliminated, pathogenic organisms are themselves transformed and disrupted. This creates opportunities for microorganisms to jump into new species and into new pathogenic behaviors. And this disruptive pressure can be subtle. For example, when microorganisms are unusually stressed, their mutation rates can increase. This is an evolutionary tactic that allows them to move on to new habitats, given that the current habitat becomes inhospitable. Over time this means that diseases that once were curable become effectively incurable. This can be seen today in diseases ranging as far as Tuberculosis, Malaria, Nipah virus, or even SARS or Swine flu. However, the outbreak of the recent COVID-19 has become a "trigger moment" in our lives. The novel pathogen that emerged in the city of Wuhan, China, in 2019 has spread to more than 70 other countries as a large scale COVID-19 epidemic. As of March 20, 2020, nearly 577,508 COVID-19 cases have been documented with nearly 26,447 deaths across the globe. COVID-19 has affected every aspect of our lives. In fact, the world is still going through the process of trial and error and does not have a clear understanding of the virus's behavior. People might wonder if this is the right time to discuss the issue of climate change? Well, the pandemic has taught us an important lesson that society needs to change. We need to understand that just as the pandemic puts all of us at risk at the same time, so does climate

change! Both have turned out to be a global crisis threatening human lives.

CAUSES AND EFFECTS OF CLIMATE CHANGE

"Climate Change is no longer some far-off problem; it is happening here; it is happening now."

-Barack Obama

Global warming is a very sensitive issue and it is another example of pervasive environmental disruption. It is leading on average, to a much higher disease burden for humans as well as other species. This is due to the fact that systematic planetary warming is necessarily having systematic effects on all parts of the globe. Global warming is an overall state of existence, i.e. the cumulative effect of hundreds of environmental factors. All of these join together in both a linear and random model to show global warming as a chain of events. The Swedish chemist, Svante Arrhenius, first predicted global warming in 1896. Since then, it has been a hotly debated topic among scientists, politicians, and environmental experts alike. (Titus 1990) The threat of catastrophic diseases is fundamentally intertwined with our impact on the environment. Disease and environment cannot be decoupled, for the problem of infectious disease is a systemic one.

All pathogenic microorganisms arise, mutate, and spread within an ecological context. As environments change and degrade due to human influence, new diseases arise and old diseases increase in lethality. This problem is further exaggerated by mankind's increase in population, mobility, and by the degradation of the urban environment, all of which are further engines for viral exploitation. It is estimated that an upward trend in global temperatures and a rise of 2.0 degrees C by the year 2100, can affect the dissemination of many serious infectious diseases. (Patz et.al, 1996) While some would call global warming theory, others would call it a proven set of facts. Opinions differ vehemently. Let us consider global warming to be both as a premise that the environment is slowly, but very surely increasing in overall air and water temperature, and a promise that if whatever is causing this trend is not interrupted or challenged life on earth will dynamically be affected. (Goodland 1995) The prevailing counter opinion is that all that is presently perceived to be global warming is simply the result of a normal climactic swing in the direction of increased temperature. Most proponents of this global warming ideology have definitive social and financial interests in these claims.

Global warming is real. It is not the result of a natural climatic adjustment. Rather, it is a quantifiable set of environmental results that are in addition to any normal changes in climate. That is why the effects of global warming have catastrophic potential. Global warming is the straw that breaks the camel's back. It is an imbalance of nature. The premise of global warming is that industrial growth coupled with non-structured methods has created a situation where our planet is getting hotter every minute. We have seemingly negatively affected our environment by a cycle of harmful processes that now seem to be feeding upon themselves to exponentially increase the damage to our ecosystem. (Khasnis 2005) According to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), the rate of extinction of species "is already at least tens to hundreds of times higher than the average rate over the past 10 million years

and is accelerating." According to IPBES, we need transformative changes across economic, social, political, and technological factors, and the goal should be to conserve mother nature in a sustainable manner. (IPBES 2020)

Already, as we read in the newspapers every day, new diseases are attacking the world. So far none of these have been 100 percent fatal for humans, until the outbreak of COVID-19. In fact, we are heading towards such an outcome where death and destruction is inevitable. There are many diseases that rely on insects as vectors in their life cycle. As insect ranges alter due to global warming or habitat alteration, for instance, the range of diseases can alter as well. We see this dynamic with certain species of mosquitoes. Over the past few decades, the range of virus-carrying mosquitoes has expanded all over the world. Thus people in temperate climates are beginning to see a range of diseases that were historically confined to tropical climates. (World Health Report 2002) Malaria has not only spread to new regions of the globe but at the same time has increased its virulence and resistance to treatment.

Likewise, dengue fever has reached Texas via Mexico (after spreading from its ancestral home in Southeast Asia). Dengue fever is at best a miserable experience and is increasingly a fatal one as well. Even the deadly disease AIDS also came about due to ecological disruption. The original ancestral HIV, known as SIV, inhabits certain African primates. In them, the virus is apparently benign. Local human populations had no problems with this virus. But with massive deforestation and mankind's increasing numbers put him into increased contact with these primates. There was a mutation and a virus jumped from primates to man. Thus HIV and AIDS were born. As Robert Green Ingersoll remarks, "in nature, there are neither rewards nor punishments; there are only consequences."

Besides, other disease outbreaks are the direct result of overpopulation, lack of sanitation, and the pollution of agricultural lands. A case in point here is hepatitis, which comes in a variety of types. All these types infect the liver, and some types are particularly virulent and lethal. Fortunately, hepatitis is not very infectious under normal conditions. In particular, sewage contamination of crops can easily spread the virus into agricultural production. In fact, it is just such contamination that has been responsible for a series of hepatitis outbreaks in Russia and the United States. As cities increasingly encroach upon agricultural lands, such outbreaks grow more likely. And the examples continue: spreading water-borne diseases in China, new forms of cholera in South America, the deadly Ebola outbreak in Africa, etc. Even the Bluetongue virus that was once confined to tropical areas, has now reached as far as Norway.

The pace continues to quicken, as the world out of ecological balance spins off new viruses and new epidemics. Likewise, there are several theories as to the origin of the COVID-19 virus, none of them wholly convincing. The U.S. government has claimed that China has been responsible for a global outbreak and that they have acted irresponsibly by hushing up valuable information from the world for a significant amount of time. It is believed that COVID-19 made its first appearance in the Chinese city of Wuhan, the capital of Hubei province that became the epicenter of the pandemic. The Huanan Seafood Wholesale Market in Wuhan

was shut down immediately on January 1, 2020, and the government also took measures to stop such markets from being the breeding grounds for zoonotic diseases. It was also claimed that the new coronavirus might have come from a lab because the research on coronavirus was being inducted at the Wuhan Institute of Virology (regarded as China's only level four biosafety laboratory) that was close to the wet market where the COVID-19 pandemic started. In the medical journal *The Lancet*, Chinese scientists claimed that the first case reported from Wuhan in December had no link to the wet market. Further, they have denied the claims reported by the World Health Organization (WHO) saying that there is hardly any evidence to support that COVID-19 is caused by human-to-human transmission. Well, whatever might have happened, the world has turned upside down. Besides, the recent outbreak of the Ebola virus in the Democratic Republic of Congo has further complicated the situation. This is the eleventh outbreak since the virus was discovered in 1976. WHO is already responding to the crisis, however, this shows that the world is fast becoming susceptible to the outbreak of deadly diseases.

Besides, pathogens, which are widely present in undisturbed forests usually, do not constitute a threat, given that man is not a natural host. However, if the preferred non-human host is removed then that creates a selection pressure for the pathogen to jump to another host. The total elimination of an ecosystem, such as a forest, is one way to eliminate a wide range of natural hosts, thus forcing pathogenic organisms into the human ecology. (Intergovernmental Panel on Climate Change 1997) Scientists have spent decades figuring out what is causing global warming. They have looked at natural cycles and events that are known to influence climate. But the amount and pattern of warming that's been measured cannot be explained by these factors alone. The only way to explain the pattern is to include the effect of greenhouse gases (GHGs) emitted by humans. To bring all this information together, the United Nations formed a group of scientists called the Intergovernmental Panel on Climate Change. The IPCC meets every few years to review the latest scientific findings and write a report summarizing all that is known about global warming. Each report represents a consensus, or agreement, among hundreds of leading scientists.

One of the first things scientists learned is that there are several greenhouse gases responsible for warming, and humans emit them in a variety of ways. Most of it is generated by the combustion of fossil fuels in cars, factories, and electricity production. The gas responsible for the most warming is carbon dioxide, also called CO2. Other contributors include methane released from landfills and agriculture (especially from the digestive systems of grazing animals), nitrous oxide from fertilizers, gases used for refrigeration and industrial processes, and the loss of forests that would otherwise store CO2. (Report of the Scientific, Environmental Effects, and Technology and Economic Assessment Panel of the Montreal Protocol 1999)

Different greenhouse gases have very different heat-trapping abilities. Some of them can even trap more heat than CO2. A molecule of methane produces more than 20 times the warming of a molecule of CO2. Nitrous oxide is 300 times more powerful than CO2. Other

gases, such as chlorofluorocarbons (which have been banned in much of the world because they also degrade the ozone layer), have heat-trapping potential thousands of times greater than CO2. But because their concentrations are much lower than CO2, none of these gases adds as much warmth to the atmosphere as CO2 does. In order to understand the effects of all the gases together, scientists tend to talk about all greenhouse gases in terms of the equivalent amount of CO2. Since 1990, yearly emissions have gone up by about 6 billion metric tons of "carbon dioxide equivalent" worldwide, which is more than a 20 percent increase.

The effects of rising temperatures aren't waiting for some far-flung future. They're happening right now. Signs are appearing all over, and some of them are surprising. The heat is not only melting glaciers and sea ice; it is also shifting precipitation patterns and setting animals on the move. Some impacts from increasing temperatures are already happening. Ice is melting worldwide, especially at the Earth's poles. This includes mountain glaciers, ice sheets covering West Antarctica and Greenland, and Arctic sea ice. (Vitousek 1997) Researcher Bill Fraser has tracked the decline of Adelie penguins in Antarctica, where their numbers have fallen from 32,000 breeding pairs to 11,000 in 30 years. Sea level rise became faster over the last century. Some butterflies, foxes, and alpine plants have moved further north or to higher, cooler areas. Precipitation (rain and snowfall) has increased across the globe, on average. Spruce bark beetles have boomed in Alaska due to 20 years of warm summers. And the insects have chewed up 4 million acres of spruce trees.

There are other effects too that could happen later this century if warming continues. Sea levels are expected to rise between 7 and 23 inches (18 and 59 centimeters) by the end of the century, and continued melting at the poles could add between 4 and 8 inches (10 to 20 centimeters). Hurricanes and other storms are becoming even stronger. Species that depend on one another may become out of sync. For example, plants could bloom earlier than their pollinating insects become active. Floods and droughts become more common. Rainfall in Ethiopia, where droughts are already common, could decline by 10 percent over the next 50 years, and less fresh water will be available. (Pimm 1995) The recent volcanic eruption in Hawaii is another example that shows how volcanic smog, or air pollution, is created by vapor, carbon dioxide, and sulfur dioxide gas released from Kilauea. Health hazards include burning eyes, headaches, and sore throats, allergies, etc. are very common these days. In fact, people who suffer from asthma or other respiratory problems may finally end up hospitalized.

If the Quelccaya ice cap in Peru continues to melt at its current rate, it will be gone by 2100, leaving thousands of people who rely on it for drinking water and electricity without a source of either. Some diseases will spread, such as malaria carried by mosquitoes. Ecosystems will change; some species will move farther north or become more successful; others won't be able to move and could become extinct. Wildlife research scientist Martyn Obbard has found that since the mid-1980s, with less ice on which to live and fish for food, polar bears have gotten considerably skinnier. Polar bear biologist Ian Stirling has found a similar pattern in Hudson Bay. He fears that if sea ice

disappears, the polar bears will as well. (Wilson 1989)

A study, by scientists at the World Health Organization (WHO) determined that 54,000 people die every year from the effects of global warming, from malaria to malnutrition, children in developing nations seemingly the most vulnerable. These numbers could almost double by 2020. “We estimate that climate change may already be

causing in the region of 154,000 deaths...a year,” Professor Andrew Haines of the London School of Hygiene and Tropical Medicine told at a climate change conference in Moscow. Haines said the study suggested climate change could “bring some health benefits, such as lower cold-related mortality and greater crop yields in temperate zones, but these will be greatly outweighed by increased rates of other diseases.” (The World Health Report 2002) Haines mentioned that small shifts in temperatures, for instance, could extend the range of mosquitoes that spread malaria. Water supplies could be contaminated by floods, for instance, which could also wash away crops. (McMichael 1996)

CONCLUSION

“The pace of global warming is accelerating and the scale of the impact is devastating. The time for action is limited - we are approaching a tipping point beyond which the opportunity to reverse the damage of CO2 emissions will disappear.”

-Eliot Spitzer

The effect of global warming depends heavily on the ability of humans and public health systems to adapt. Human migration and economic stresses from climate variability could threaten human settlement and seriously overwhelm the public health infrastructure. This scenario might be worsened further by malnutrition due to crop failure. (Baillie 1996) Facing this complex threat makes interdisciplinary cooperation among health professionals, climatologists, environmental biologists and social scientists imperative to understand and effectively manage this threat that could result from global warming. (Khasnis and Nettleman 2005) A renewed understanding of linkages between public health and the global life-support system is constantly emerging in the literature. (Goodland 1995) New collaborative efforts can confront these tough challenges through advances in preventive medicine. In much of the world, the current increasing life expectancy is likely to be blunted by increased difficulty in accessing basic requirements such as sewage, sanitation, and potable water (safe to drink). The direct and indirect impacts of climate change on human health have a considerable toll on life, resources, (natural and financial) and working manpower. Altered environmental influences would also mean courting environmental disasters such as famines and floods. Even non-vector-borne infectious diseases, such as salmonellosis, cholera, and giardiasis can thrive under these circumstances. (IPCC Working Group 1997) Thus, the impact of climate change depends on several factors. Although exact predictions are impossible, there are significant areas of concern throughout the world. (IPCC Working Group 2001)

There are abundant pieces of evidence that human beings are beginning to alter some of the planet’s basic physical, chemical and biological systems, endangering other species

and disrupting ecosystems in the process and ultimately threatening human health. (McMichael 1996) When Homo sapiens evolved some 120,000 years ago, the number of species on Earth was the largest ever, (Wilson 1989) but human activity has resulted in species extinction rates that are currently 100 to 1000 times the pre-human rate. (Pimm 2000) Although the record demonstrates that humans hunted to extinction scores of large mammals and birds as early as tens of thousands of years ago, it is only in recent times that these extinctions have spread to virtually every part of the planet and to almost every phylum. (Chivian 2001)

Species numbers are now being reduced so rapidly that some experts have predicted that 25 percent or more of all species currently alive may become extinct during the next 50 years if these rates persist. (Baillie 1995) Such losses have prompted biologists to refer to the present period as "the sixth extinction" (the last great extinction event, the fifth, was 65 million years ago, at the end of the Cretaceous period, when dinosaurs became extinct) and to warn that evolutionary processes would not replace these losses with a stock of new species for several million years. (Pimm, 2000) From this perspective, the loss of species maybe said to be the most destructive and permanent consequence of human-caused degradation of the global environment. Global climate change, stratospheric ozone depletion, chemical pollution, acid rain, the introduction of alien species and the over-hunting of species all threaten biodiversity, but it is the degradation, reduction, and fragmentation of habitats that are the greatest threat, particularly in species-rich areas such as tropical rainforests and coral reefs. (Pimm 2000)

The World leaders should gather together to hammer out and adopt a strong and equitable climate change agreement that utilizes health impact as a key factor in prioritizing action. In particular, this movement will focus on decisive climate change actions and mitigation policies that can potentially yield enormous benefits to global health. However, the world was in a state of shock when President Trump decided to leave the Paris Agreement. There are doubts that without U.S. participation, nations could relax their CO2 emissions reduction efforts. But dialogue and discussion should continue and such a step shouldn't cast a shadow on our long-term efforts to resolve the climate problem. In fact, the World Health Organization (WHO) is keen to create a platform for continued action through and beyond Copenhagen on all levels. The launching of the global "Go Green for Health" movement in Copenhagen was a milestone event to advocate for health sector leadership in implementing the COP-15 agreements.

Nevertheless, the purpose of COP-15, which is the prompt communication of accurate information, will likely be fulfilled when the cooperation among nations will become genuine; there will be no weak links in the process cycle, and governments will be acutely sensitive to the dangers of global warming. The December 2018 Katowice COP-24 conference took place in Poland to ensure the effective implementation of such provisions of the convention. The talk resulted in nearly 200 nations agreeing to a set of rules that will govern the Paris Agreement on climate change. Countries even agreed to limit warming to 1.5 degrees Celsius over pre-Industrial levels. We hope that this will help to ensure comprehensive and continuing

linkages between health and climate change adaptation, mitigation campaigns, as well as policy actions. While flexible mechanisms were the most central point and object of extensive discussion in the Kyoto Protocol, but at COP7 in Marrakesh in 2001 an agreement was reached on their ultimate form. And now at COP-24, world leaders gathered to enhance the last resort to "change" our response to the climate crisis.

In 2020, we are asking ourselves the question of whether we are heading towards a COVID-19 recession? If yes, then whom should we blame and who is the bad guy? Is it a result of pursuing globalization in an aggressive and unwise manner? We are at the edge of globalization where our survival extends far beyond the boundaries of any country, and neither it is dependent on ethnicity, race, religion, or culture, etc. It looks like globalization has turned the world glocal (global + local) where each country is fighting the pandemic together to welcome a 'new normal.' As environmentalist Barry Commoner mentioned that the first law of ecology is "everything is connected with everything else." To conclude, proper environmental management is the key to avoiding a quarter of all preventable illnesses that are directly caused by environmental factors. We hope that global cooperation, policy, and politics will help to control the spread of infectious diseases and reduce environmental problems that are causing global warming. After all, as David Thoreau once said: "what is the use of a house if you haven't got a tolerable planet to put it on?"

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