THE CORONA VIRUS IS THE "PEARL HARBOR" OF CLIMATE CHANGE. LET'S START ACTING LIKE IT!

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Humans have known that climatic conditions affect epidemic diseases from long before the role of infectious agents was discovered. Late in the nineteenth century. Roman aristocrats retreated to hill resorts each summer to avoid malaria. South Asians learned early that, in high summer, strongly curried foods were less likely to cause diarrhea. Viruses like SARS-CoV-19, desertification, dying coral reefs and species extinction are all part of the bigger picture of global warming and its outcome Climate Change. Climate disruption continues its relentless progress in spite of trillions of dollars spent and countless hours of meetings and endless salaries paid to environmental groups.

How much more painful a wake-up call than a Corona Virus Pandemic do we need before we take action? It's as if Pearl Harbor had been bombed, and instead of fighting the Japanese, we all went inside our houses to play video games. Yes, as usual, we need to clean up the current mess, but then we need to get on "war footing" and *confront the underlying problem*. The Omnicide Complaint currently before the International Criminal Court could press nations to finally come together and begin the relatively simple matter of Direct Air Carbon Capture to stabilize CO_2 levels in the atmosphere. We have the technology to remove excess carbon directly from the atmosphere and could re-stabilize from our current 420 ppm atmospheric carbon to a pre-industrial 280 ppm within a few years! It's easier than fighting a pandemic, or a war, and has a zero-casualty rate versus hundreds of thousands.

Whacking Moles, But Never Catching Up

Like building seawalls around Manhattan Island and other expensive stop-gap measures, the real danger is not the current battle, it is the underlying problem – the disruption of our biosphere - about which we are doing little that is effective. The threat that should make us anxious is *we are well on our way to squandering all our resources* playing whack-a-mole with various viruses and bacterium, severe weather events, altered migration patterns, etc. As our resources dwindle and climate change events become more severe, we will lose our ability to get in front of the problem – or even catch up. Infectious diseases and the development of novel communicable diseases (HIV/AIDS, hantavirus, hepatitis C, SARS, malaria, dengue fever, yellow fever) and zoonoses (e.g. bubonic plague and Lyme disease, etc.) are only one part of that process.

No virus, bacterium, wildfire, or extinction is solely attributable to global warming. However, research emerging from such luminary institutions as the World Health Organization, NASA, Stanford University, Princeton University, John's Hopkins University have established a clear relationship between increased global temperatures and many of the most significant problems confronting our civilization. Researchers are confident this reflects the combined impacts of rapid demographic, environmental, social, technological and other changes in our environment caused by global warming.

Climate Change is Increasing the Range of Disease Vectors

One major shift caused by climate disruption are the determinants of vector-borne disease which include: (i) vector survival and reproduction, (ii) the vector's biting rate, and (iii) the pathogen's incubation rate within the vector organism. Vectors, pathogens and hosts each survive and reproduce within a range of optimal climatic conditions: temperature and precipitation are the most important, while sea level elevation, wind, and daylight duration are also important. Stanford biologist Erin Mordecai and her colleagues have made startling forecasts of how climate change will alter where mosquito species are most comfortable and how quickly they spread disease, shifting the burden of disease around the world. Mosquitoes and other biting insects transmit many of the most important, devastating and neglected human infectious diseases, including malaria, dengue fever, chikungunya and West Nile virus. Economic development and cooler temperatures have largely kept mosquito-borne diseases out of wealthier Northern Hemisphere countries, but climate change promises to tip the scales in the other direction.

Because the many mosquito species adapt to different temperature bandwidths higher global temperatures will decrease the chance of most vector-borne disease spreading in places that are currently relatively warm. Unfortunately for most of the world, warming will increase the chance that all diseases spread in places that are currently relatively cool such as North America and Europe. Projective models suggest climate change will results in 96 million dengue cases a year."

Malaria is of great public health concern and seems likely to be the vector-borne disease most sensitive to long-term climate change. Malaria varies seasonally in highly endemic areas. The link between malaria and extreme climatic events has long been studied in India, for example. Early last century, the river-irrigated Punjab region experienced periodic malaria epidemics. Excessive monsoon rainfall and high humidity was identified early on as a major influence, enhancing mosquito breeding and survival. Recent analyses have shown that the malaria epidemic risk increases around five-fold in the year after an El Niño event.

Waterborne infections are also on the increase, transmitted by contact with contaminated drinking water, recreational water, or food. This may result from human actions, such as improper disposal of sewage wastes, or be due to weather events. Changes in rainfall can influence the transport and dissemination of infectious agents, while temperature affects their growth and survival.

And when these viruses move from insects and animals to humans, they can cause serious harm to people quickly. It's not only climate, but it's subset, the weather, that has an effect on how much a virus spreads. The flu, for example, survives longer in the air when it is humid as compared with drier air. So, climatic conditions definitely facilitate transmission.

Animals Increasingly in Conflict with Humans

Based on a thorough search of available data in the literature, the researchers now report on a global analysis of abundance trends for 304 widely distributed marine species over the last century. The results show that -- just as predicted -- abundance increases have been most prominent where sampling has taken place at the poleward side of species ranges, while abundance declines have been most prominent where sampling has taken place at the equatorward side of species ranges. This is also true for land animals who are failing to adapt to climate disruption and being forced out of their natural rhythms and habitats.

The findings show that large-scale changes in the numbers of species are well underway. They also suggest that marine species haven't managed to adapt to warmer conditions. The researchers therefore suggest that projected sea temperature increases of up to 1.5°C over pre-industrial levels by 2050 will continue to drive the latitudinal abundance shifts in marine species, including those of importance for coastal livelihoods.

"This matters because it means that climate change is not only leading to abundance changes, but intrinsically affecting the performance of species locally. The main surprise is how pervasive the effects were," says the senior author of one study Martin Genner, an evolutionary ecologist at the University of Bristol. "We found the same trend across all groups of marine life we looked at, from plankton to marine invertebrates, and from fish to seabirds."

Climate Change is Waking Sleeping Dogs

"Following our work and that of others, there is now a non-zero probability (geek-speak for no chance at all) that pathogenic microbes could be revived by planetary warming, and infect us," says evolutionary biologist Jean-Michel Claverie at Aix-Marseille University in France "Just how likely that is, is not known, but it's a probability and we have to address it. It could be bacteria that are curable with antibiotics, or resistant bacteria, or a virus. If the pathogen hasn't been in contact with humans for a long time, then our immune system would not be prepared. Frozen permafrost soil is the perfect place for bacteria to remain alive for very long periods of time, perhaps as long as a million years." That means melting ice could potentially open a Pandora's box of diseases. "Permafrost is a very good preserver of microbes and viruses, because it is cold, there is no oxygen, and it is dark," says evolutionary biologist Jean-Michel Claverie at Aix-Marseille University in France. "Pathogenic viruses that can infect humans or animals might be preserved in old permafrost layers, including some that have caused global epidemics in the past."

In the early 20th Century alone, more than a million reindeer (yes, reindeer are real) died from anthrax. It is not easy to dig deep graves, so most of these carcasses are buried close to the surface, scattered among 7,000 burial grounds in northern Russia. In a 2005 study, NASA scientists successfully revived bacteria that had been encased in a frozen pond in Alaska for 32,000 years. The microbes, called Carnobacterium pleistocenium, had been frozen since the Pleistocene period, when woolly mammoths still roamed the Earth. Once the ice melted, they began swimming around, seemingly unaffected. Once revived the viruses quickly became infectious

Two years later, scientists managed to revive an 8-million-year-old bacterium that had been lying dormant in ice, beneath the surface of a glacier in the Beacon and Mullins valleys of Antarctica. In the same study, bacteria were also revived from ice that was over 100,000 years old. In a 2014 study, a team led by Claverie revived two viruses that had been trapped in Siberian permafrost for 30,000 years. Known as Pithovirus sibericum and Mollivirus sibericum, they are both "giant viruses", because unlike most viruses they are so big they can be seen under a regular microscope. (Giant viruses are almost impossible to kill.) They were discovered 100ft underground in coastal tundra.

Immune System Challenge

Another worry is the reality that rising temperatures are making our natural immune systems less effective. Our bodies are amazing disease-fighting machines. One adaptation goes a long way: our warm body temperature can by itself shut down all sorts of unwanted invasions. When a pathogen enters our body, we often get a fever, warming us up even more to fight off disease. Fevers stimulate the immune system and, ideally, the heat creates an environment where it's difficult for pathogens to survive.

But, as pathogens are exposed to gradually warmer temperatures in the natural world, they become better equipped to survive the high temperature inside the human body. "Every time we have a very hot day, we have a selection event," says Arturo Casadevall, a professor of microbiology and immunology at Johns Hopkins University's Bloomberg School of Public Health. The pathogens that survive—and reproduce—are better adapted to higher temperatures, including those in our bodies. And, with that, one of our body's primary defense mechanisms diminishes in effectiveness.

For Those Science-Minded Among Us - Where Is This Data Coming From?

There are three categories of research into the linkages between climatic conditions and infectious disease transmission. The first examines evidence from the recent past of associations between climate variability and infectious disease occurrence. The second looks at early indicators of already-emerging infectious disease impacts of long-term climate change. The third uses the above evidence to create predictive models to estimate the future burden of infectious disease under projected climate change scenarios.

Statistical models require, first, the derivation of a statistical (empirical) relationship between the current geographic distribution of the disease and the current location-specific climatic conditions. This describes the climatic influence on the actual distribution of the disease, given prevailing levels of human intervention (disease control, environmental management, etc.). By then applying this statistical equation to future climate scenarios, the actual distribution of the disease in future is estimated, assuming unchanged levels of human intervention within any particular climatic zone. These models have been applied to climate change impacts on malaria, dengue fever and, within the USA, encephalitis. For malaria some models have shown net increases in malaria over the coming half-century, and others little change.

Process-based (mathematical) models use equations that express the scientifically documented relationship between climatic variables and biological parameters – e.g., vector breeding, survival, and biting rates, and parasite incubation rates. In their simplest form, such models express, via a set of equations, how a given configuration of climate variables would affect vector and parasite biology and, therefore, disease transmission. Such models address the question: "If climatic conditions alone change, how would this change the potential transmission of the disease?" Using more complex "horizontal integration", the conditioning effects of human interventions and social contexts can also be incorporated.

This modelling method has been used particularly for malaria and dengue fever. The malaria modelling shows that small temperature increases can greatly affect transmission potential. Globally, temperature increases of 2-3ºC would increase the number of people who, in climatic terms, are at risk of malaria by around 3- 5%, i.e. several hundred million. Further, the seasonal duration of malaria would increase in many currently endemic areas.

Since climate also acts by influencing habitats, *landscape-based modeling* is also useful. This entails combining the climate-based models described above with the rapidly-developing use of spatial analytical methods, to study the effects of both climatic and other environmental factors (e.g. different vegetation types – often measured, in the model development stage, by ground-based or remote sensors). This type of modelling has been applied to estimate how future climate-induced changes in ground cover and surface water in Africa would affect mosquitoes and tsetse flies and, hence, malaria and African sleeping sickness.

Logical Conclusions

Many people have questioned why *this* particular corona virus pandemic has caused *so* much panic. Perhaps our global society is blowing off collective steam, venting anxiety about climate change we don't want to, or feel powerless to deal with onto a more tangible and controllable threat. Individually we can't remove carbon from the atmosphere, but we can buy toilet paper! Panic is never helpful, but waking up to the reality that we are in a larger emergency is essential. SARS-CoV-19 must be our Climate Pearl Harbor.

We must get in front of the broader crisis before individual crises like our present pandemic overwhelm our ability to respond effectively. Remember that hurricane and fire seasons are only a few months away, massive migrations are still taking place, a catastrophic weather event is likely any time, coral reefs are dying off, and floodwaters are continuing to rise. So far, we are *lucky* to be just getting hit by *increasingly frequent* adverse events. What will if be like when *multiple* catastrophic events are overlapping at the same time? That is the world we are rushing toward and, unless we change course, will be leaving to our children. Join us *now* in the fight at the Climate Deadline Alliance **www.climatedeadline2035.com** *while there is still time*.