Rita R. Colwell

Global Climate and Health

Predicting Infectious Disease Outbreaks

Over the past decade, the complexity of climate change has been the subject of extensive discussion. However, microbial factors associated with climate change, notably infectious diseases, are rarely, if ever, included in climate models. Although the problem is complicated and the interactions involved are both multidisciplinary and interdisciplinary, the human health aspect must be considered nevertheless if global effects of climate change are to be fully understood.

Few will dispute that global warming is occurring. Over the past few years, the highest average temperatures have been recorded, with 2005 the highest in history. Ocean and land surface annual temperatures have increased, with sea surface levels predicted to rise accordingly.[1]

Despite the U.S. Surgeon General's report in the mid-1950s declaring the war on infectious disease to be over as a result of the discoveries of powerful antibiotics, infectious diseases remain serious threats to global health. Acute respiratory infections, including pneumonia and influenza (avian influenza is a looming threat), are the number one killer, but for children under the age of five, diarrheal disease remains a major killer, especially in developing countries.

Cholera, a diarrheal disease caused by bacteria, has afflicted humankind over the ages, as evidenced by reference to it in ancient Sanskrit writings. Cholera has occurred in global pandemics, notably in India and Bangladesh,

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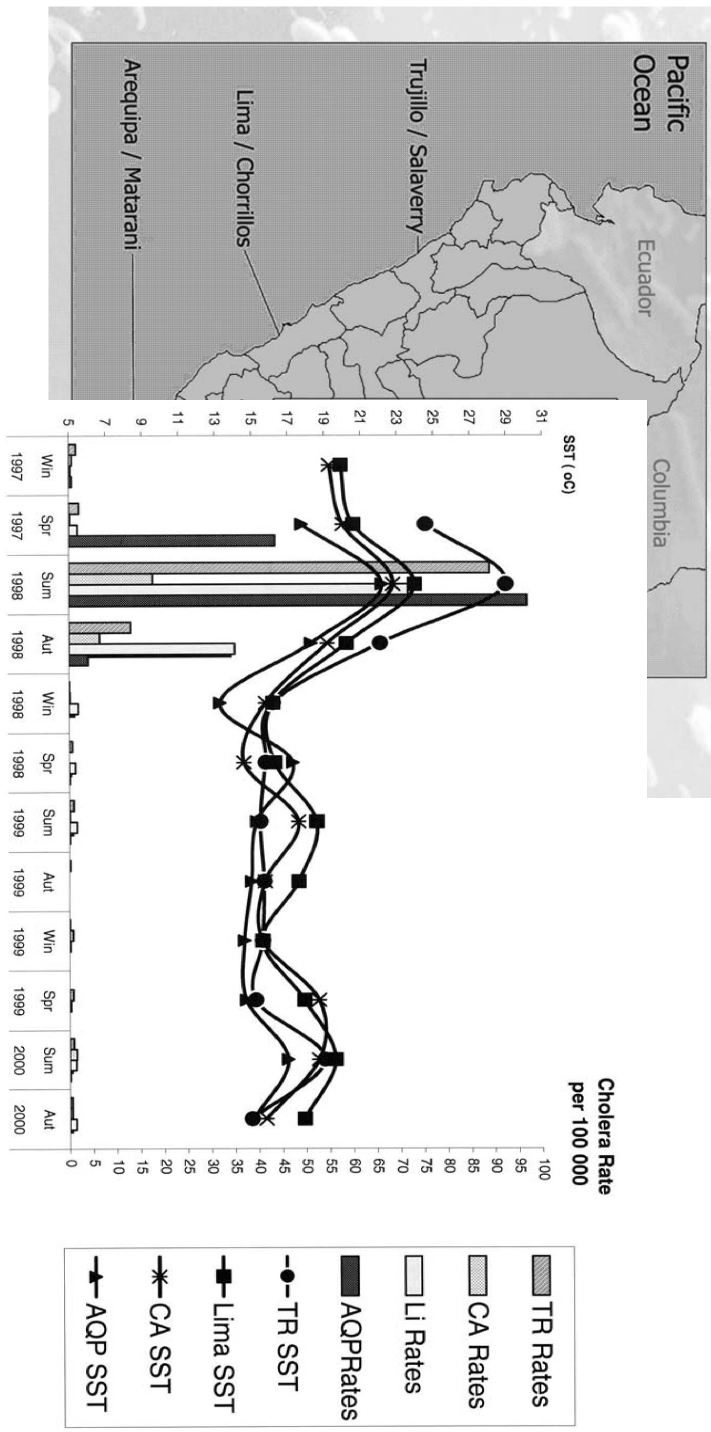

Figure 1. Populations of Cholera Bacteria Related to El Nino Sea-Surface Temperatures, 1997-1998

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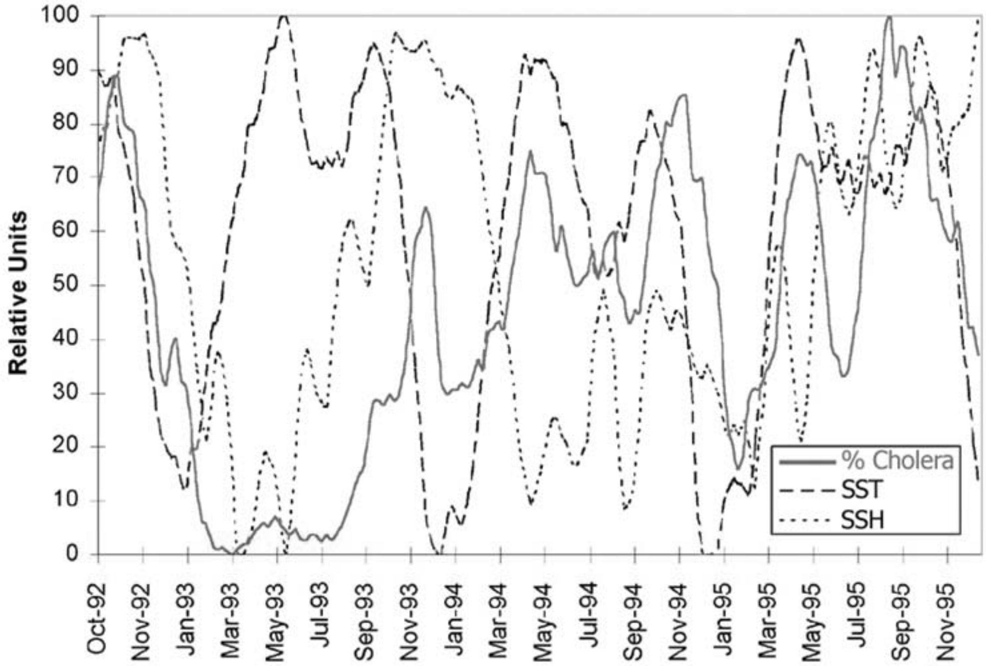

Figure 2. Cholera Outbreaks and Increases in Sea-Surface Temperature (SST) and Sea-Surface Height SSH)

Source: B. Lobitz et al. "Climate and infectious disease" PNAS (February 2000, vol. 97, no.4)

but more recently in Latin America and with serious consequences in Africa. Until the nineteenth century, cholera was generally confined to the Indian subcontinent, but it erupted in Europe and the Americas with the first recorded pandemic in 1817. The second recorded pandemic included the United States in 1832, i.e. New York, Philadelphia, Washington, DC, and the Atlantic Coast to the Gulf of Mexico. Medical history describes seven global pandemics of cholera over the past 200 years that have spread illness and death.

In 1977, *Vibrio cholerae*, the bacteria that cause cholera, were isolated from the Chesapeake Bay in Maryland.[2] This finding was the first report of the cholera vibrio in a noncholera-endemic geographical area, as cholera had not been reported in Maryland since the 1900s. The cholera vibrio was shown to be a native inhabitant of the Chesapeake Bay and other bays, estuaries, and rivers of temperate and tropical regions. With application of molecular techniques, the bacterium now is recognized as naturally occurring in the aquatic environment. The bacterial population peaks twice annually (spring and fall), in association with plankton blooms. Rivers, estuaries, and coastal waters are now known to be reservoirs of these bacteria globally. This new understanding of

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the environmental source of the cholera bacteria produced a paradigm shift for the medical community—cholera had been believed to be transmitted only by person-to-person contact, but the bacteria are now recognized to exist in the environment as a natural inhabitant. The bacteria have been observed also to have a dormant stage in the environment between epidemics.

A relationship between the increase in sea-surface temperature and the onset of cholera epidemics has been observed, with the seasonal pattern of cholera following the seasonal rise and fall in sea-surface temperature and height.[3] A concomitant relationship exists between the cholera bacteria and plankton populations: In the spring, when surface water warms, phytoplankton first become abundant, utilizing sunlight for energy. The surge in phytoplankton is followed by blooms of zooplankton. The zooplankton blooms are associated with increases in cholera bacteria.

In 1991–1992, an unprecedented cholera epidemic occurred in Peru, resulting in approximately 200,000 cases and 5,000 deaths. Cholera had not been reported in South America for nearly 100 years, and, notably, the epidemic occurred during an unusually strong El Niño cycle. When the next El Niño was predicted in 1997–1998, we were prepared to study the relationship between cholera and El Niño events. As El Niño caused the sea-surface temperature off the coast of Latin America to rise in 1997, the presence of cholera bacteria associated with plankton was recorded. The numbers of the bacteria increased from spring to summer (September 1977 to March 1998), and cases of cholera increased, with a slight lag (late November through May 1998). These cases, therefore, showed significant correlation with sea-surface temperature (Figure 1).

A similarly definable relationship between sea-surface temperature, sea-surface height, and cholera epidemics had been established earlier for Bangladesh (Figure 2).[4]

Thus, the complex factors of sea-surface temperature, sea-surface height, zooplankton populations, and other environmental parameters provide a predictive capacity for cholera epidemics that draws from climate monitoring via satellite sensors and other environmental data.

Global warming can profoundly change the patterns of infectious diseases. Cholera, which is so strongly intertwined with the environment, serves as a paradigm. Climate can profoundly influence the geographic range and intensity of other diseases that are vectorborne (e.g., malaria, hanta virus, dengue). Both vectorborne disease and waterborne diseases such as cholera will pose enhanced threats in parts of the world.

Climate change can be expected to influence the earth's biological systems. In climate models, human factors, notably global infectious disease and human health, cannot be omitted. The interaction of humans, cholera bacteria, plankton, and other environmental factors provides the basis for reasonable predic-

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tions about cholera disease outbreaks. Other climate-driven diseases may also prove similarly measurable. Understanding and modeling the role of climate change in the spread of infectious diseases is paramount to a holistic understanding of the consequences of global climate change and, certainly, for policies addressing societal needs related to global climate change.

We invite reader comments. Email <editors@innovationsjournal.net>.

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