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CLIMATE CHANGE MAY AFFECT PLAGUE DISTRIBUTION AND INCIDENCE

- *Good news about global warming? New fifty-year analysis explores the link between climate factors and plague epidemics in the United States –*
- *Study reveals that as temperatures are rising and levels of snowfall are decreasing, incidences of the plague are decreasing –*

Deerfield, IL, (Sept. 7, 2010) – While many climate experts and environmentalists explore the negative effects of global warming, a new study reveals a positive outcome of the warming of the planet: the potential elimination of the plague. Global warming affects temperatures and precipitation regimes that play a pivotal role in the lives of rodents and fleas; rodents and fleas are responsible for maintenance and spread of plague to human populations. Plague can be fatal if the symptoms are not recognized and treated within 24 hours.

The study, featured in the September issue of the *American Journal of Tropical Medicine and Hygiene (AJTMH)*, revealed incidences of plague in the western United States are decreasing as global warming raises temperatures and decreases snowfall in the area. The study examined a 56-year time series of plague reports (1950-2005), in conjunction with temperature and precipitation records, to determine the effect of large-scale climate variability on the dynamics of human plague in the region.

The study analysis suggested that snow may play a key role in the relationship between climate and plague; snow affects the summer soil moisture, which is known to be instrumental for flea survival and the development and sustained growth of vegetation for rodents. The effects of global warming will likely result in increasingly unfavorable conditions for fleas, creating less favorable conditions for increases in the rodent population. These factors suggest that plague in the western United States is likely to decrease in the coming decades.

“Following analysis of 56 years worth of climate and plague data, we are encouraged that prevalence of the plague is decreasing, likely due to environmental factors. However, in places like New Mexico where human-population movement into the desert is likely to continue, plague exposure and risk could still occur on a local basis,” said Nils Chr. Stenseth, Professor, Centre for Ecological and Evolutionary Synthesis, University of Oslo. “As recently as August 2010, an outbreak of plague was reported in Peru in a coastal village, which suggests plague is still a modern healthcare concern. People should be more vigilant and monitor it.”

There are three types of the plague – bubonic, septicemic, and pneumonic. Plague exists in nature due to the transmission between hosts (wild rodents) and vectors (fleas), and is caused by the bacterium *Yersinia pestis*. Typically, rodents spread the disease to humans, or people can get

the plague when they are bitten by a flea that carries the plague bacteria from an infected rodent. Certain forms of the plague can be spread from human to human. Unless treatment is received within 24 hours of the first symptoms, death from the plague may be unavoidable. Antibiotics, oxygen, intravenous fluids, and respiratory support are usually needed to treat the plague.

“With the recent reported cases of dengue fever in the United States, Americans are becoming more aware of the dangers associated with vector-borne diseases. Like dengue fever, plague is a vector-borne disease. Despite the fact that millions of people are infected with a vector-borne disease each year, including tens of thousands of Americans, many people are unaware that weather affects vector populations and disease transmission,” said Edward T. Ryan, M.D., President, American Society of Tropical Medicine and Hygiene (ASTMH). “Only recently through scientific research have we started to understand how climate change might affect the distribution of vector-borne diseases, and this study provides good insight into how climate will impact the spread of plague in the United States.”

In the Middle Ages, massive plague epidemics killed millions of people. Today, plague cases occur regularly in the western United States; cases have been reported in parts of California, Utah, Arizona, Nevada, and New Mexico. Globally, the World Health Organization reports 1,000 – 3,000 cases of the plague each year. Presently, rat control and surveillance for the disease in the wild rodent population are the main measures used to control the risks of plague epidemics.

About the study

Plague data:

Annual counts of human plague cases in the counties of exposure available from 1950 to 2005 were analyzed. All 105 counties (distributed across 13 states), reporting at least one plague case over the study period, were considered. No correlation exists between plague outbreak frequency and population density at the county level. The largest human plague outbreaks typically occur in primarily rural counties with close to media population density. Plague counts are adjusted by county population density to produce county-level human-plague time series compatible with the climate.

Climate data:

Extensive temperature and precipitation records are freely available for thousands of available meteorological stations in the United States. From these records, 100 stations were chosen with the highest quality data (defined as those with the fewest missing data point and the highest proximity to plague counties) to build proxies for monthly temperature and precipitation regimens across the western United States.

Climate variability over the western United States is primarily characterized by two modes of fluctuations: the Pacific Decadal Oscillation (PDO; decadal time periods) and El Niño Oscillation (ENSO, 3-to-4 year time periods). Positive PDO and ENSO phases are both associated with wetter and milder climate over the western United States. These large-scale climate indices are known to be efficient predictors of ecological processes in other systems, including the rodent population dynamics and demographic rates.

Wavelet analyses:

In nature, non-stationary processes are common, and increasing evidence suggests the importance of transient dynamics in ecological processes. Epidemiological time series are typically noisy, complex, and strongly non-stationary. Wavelet analyses provide powerful tools for analyzing such signals. It is well-suited to dealing with transient relationships between two signals (e.g., climate interaction with the dynamics of an epidemic). Wavelet analysis performs a time-frequency decomposition of the signal and allows one to follow the evolution of the different frequency components as time progresses. Wavelet analysis and its bivariate

extensions, wavelet cross-spectrum and wavelet coherency, were used to analyze the plague data and their statistical relationship with the climatic time series.

Study results:

The study results were as follows:

- PDO and ENSO affect precipitation and primary production in the western United States. PDO exhibits coherent positive correlations with late winter/early spring precipitation throughout the area. Consistent positive precipitation anomalies occur in late winter to spring when PDO is high; this pattern is most marked when El Nino events combine with positive PDO. Conversely, a low PDO/La Nina combination results in below normal precipitation. Snow anomalies (measured as the amount of water precipitated on days when the daytime temperature is below freezing) are also higher during El Nino/PDO positive phases.
- PDO and ENSO significantly explain the temporal variability of plague cases. To explore human-plague patterns across the whole region, the spatial sum of all population density-scaled human cases were used. Plague outbreaks occur predominantly during positive phases of PDO. The correlation between the plague time series and the ENSO index alone is generally not significant. Periods of high plague occurrence seem to occur when El Nino events coincide with a positive PDO phase.
- Climate change. The study analysis explored the possible effect of climate change in the 1990s to explain discrepancies between the expected and observed number of plague cases. Indeed, the 1998 El Nino event occurring at high PDO did not result in above-normal plague cases. However, above-mean counts of hot counts were recorded in 1998 at all stations, which should be detrimental to plague; warm nighttime temperatures also were observed at this time. Climate change has been pointed out by some as partly responsible for these trends, and nighttime temperatures have slightly increased in the west since 1990. In case these trends continue, some have proposed that areas of recurrent plague activity (i.e., endemic areas) will shift to higher latitudes/elevations. The data indicates a trend to higher elevation/latitude, but this trend may have started in the 1980s and is not significant; the use of exposure-site data for cases rather than county-level data could provide more specific conclusions to be made on the possible role of climate change on what locations will have the greatest amounts of human-plague activity in the future, but such analyses are outside the scope of the current study.

About the ASTMH

The American Society of Tropical Medicine and Hygiene (ASTMH), founded in 1903, is a worldwide organization of scientists, clinicians and program professionals whose mission is to promote global health through the prevention and control of infectious and other diseases that disproportionately afflict the global poor.

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