NIH study sheds light on role of climate in influenza transmission

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Two types of environmental conditions—cold-dry and humid-rainy—are associated with seasonal influenza epidemics, according to an epidemiological study led by researchers at the National Institutes of Health's Fogarty International Center. The paper, published in *PLOS Pathogens*, presents a simple climate-based model that maps influenza activity globally and accounts for the diverse range of seasonal patterns observed across temperate, subtropical and tropical regions.

The findings could be used to improve existing current influenza transmission models, and could help target surveillance efforts and optimize the timing of seasonal vaccine delivery, according to Fogarty researcher Cecile Viboud, Ph.D., who headed the study. "The model could have a broader application, encouraging researchers to analyze the association between climatic patterns and infectious disease across a wide range of diseases and latitudes," said Viboud.

Human influenza infections exhibit a strong seasonal cycle in temperate regions, and laboratory experiments suggest that low specific humidity facilitates the airborne survival and transmission of the virus in temperate regions. Specific humidity is the ratio of water vapor to dry air in a particular body of air while relative humidity—commonly used in weather forecasts—is the amount of water vapor in the air relative to its capacity to hold water vapor, and is primarily a function of temperature.

Data from animal studies indicate low temperature and humidity increase the duration of the virus's reproduction and expulsion in infected organisms and virus stability in the environment, increasing the probability of transmission through coughing, sneezing or breathing. In contrast, high temperature seems to block airborne transmission.

According to James Tamerius, Ph.D., a geographer at Columbia University, New York City, and the first author of the study, the effect of low specific humidity on influenza could cause annual winter epidemics in temperate areas. "However, this relationship is unlikely to account for the epidemiology of influenza in tropical and subtropical regions where epidemics often occur during the rainy season or transmit year-round without a well-defined season," he said.

After assessing the role of local climatic variables on virus seasonality in a global sample of study sites, Viboud and her colleagues found that temperature and specific humidity were the best individual predictors of the months of maximum influenza activity, known as influenza peaks. The team discovered that in temperate regions, influenza was more common one month after periods of minimum specific humidity. These periods happen to coincide with months of lowest temperature. In contrast, sites that maintained high levels of specific humidity and temperature were generally characterized by influenza epidemics during the most humid and rainy months of the year. "The models we used predicted the timing of peak influenza activity with 75 to 87 percent accuracy," said Viboud.

"Anecdotal evidence suggests that colder climates have winter flu while warmer climates that experience major fluctuations in precipitation have flu epidemics during the rainy season, and the current study fits that pattern," said Viboud. "In contrast, the seasonality of influenza is less well-defined in locations with little variation in temperature and precipitation, and is a pattern that remains poorly understood. One hypothesis that is often used to explain tropical influenza activity is that people congregate indoors more frequently during the rainy season, increasing contact rates and disease transmission. There is little data to confirm this, however, and it's an interesting area for future research."

To reach these conclusions, the researchers used a recently developed global database that provides information on influenza peaks from 1975-2008 for 78 sites worldwide. The study spanned a range of latitude that was between 1 and 60 degrees, with 39 percent of the sites located in the tropics. Additionally, epidemiological data from nine countries participating in FluNet, the World Health Organization's global influenza surveillance program, was used to ensure independent validation. The nine countries—including Spain, Tunisia, Senegal, Philippines, Vietnam, Colombia, Paraguay, South Africa and Argentina— were not represented in the original 78-location database and were chosen because each country provided several years of data.

"We've shown the importance of thresholds in humidity and temperature which are predictive of whether influenza activity occurs during winter months, the rainy season or throughout the year," said Viboud. "The predictions of our climate-based models compared favorably to epidemiological information collected independently of the dataset used for the model-building exercise."

Though the study offers researchers a new tool in the global effort to track the spread of influenza, climate is only one of several potential drivers of influenza seasonality. "Further work should focus on examining the role of population travel and other factors in influenza transmission," notes Mark Miller, M.D., director of Fogarty's Division of International Epidemiology and Population Studies. "

More broadly, additional analysis of the link between climate and infectious diseases is needed— particularly for respiratory and intestinal pathogens that display marked seasonality." The authors conclude, "A better understanding of the environmental, demographic and social drivers of infectious disease seasonality is crucial for improving transmission models and optimizing interventions."

More information: dx.plos.org/10.1371/journal.ppat.1003194

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