Does Climate Predict the Timing of Peak Influenza Activity in the United States?

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Objective

To assess the strength of the association between peak influenza activity and dew point, average daily temperature, solar radiation, latitude and longitude so that we may better understand the factors that affect virus transmission and/or innate immunity and to determine whether these climate variables should be used as covariates in the surveillance of influenza.

Background

Though spatio-temporal patterns of influenza spread have often suggested that environmental factors, such as temperature, solar radiation and humidity play a key role, few studies have directly assessed their effect on the timing of annual epidemics. Finkelman et al (2007) observed a significant positive relationship between the latitudinal position of temperate countries and epidemic timing [1]. It is hypothesized that during winter months, in temperate regions, decreased skin exposure to sunlight affects immune function by altering the production of certain immunomodulators (e.g. melatonin and Vitamin D_3) [2, 3]. Other studies have linked temperature and humidity conditions to the rate of transmission of the influenza virus [4, 5].

Methods

For each influenza season in the study period 2000-2005, we identified the week of peak influenza activity for 35 cities in the United States using pediatric hospitalization visits with ICD-9 codes equal to 486.00, 487.00, 487.10 or 487.7. Selection of peak week was also guided by regional viral isolate data and Respiratory Syncytial Virus hospitalization data. Bayesian hierarchical models were used to assess the strength of association between each of the climate variables (averaged over October to December) and geographic coordinates with the timing of the epidemics.

Results

Solar radiation was negatively associated with epidemic timing (95% CI: (-0.027, -0.004)). We did not find a significant relationship between either dew point or average daily temperature and the timing of peak influenza activity. Latitude but not longitude was associated with the timing of the epidemics (95% CI: (0.026, 0.24)). The four cities in Texas were on average 3 weeks earlier than other US cities (-3.12, 95% CI: (-4.65, -1.56)).

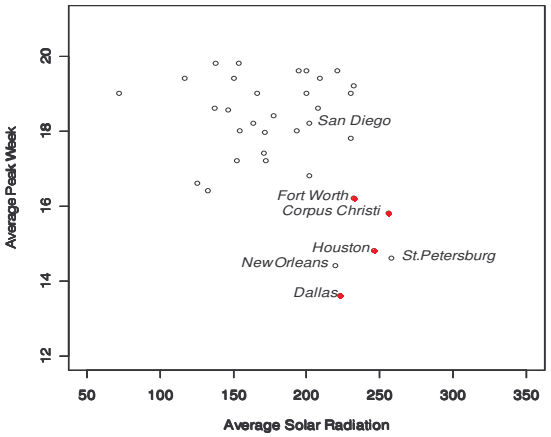

FIGURE 1: Average week of peak influenza activity versus solar radiation for 35 US cities averaged over the five influenza seasons in the study period, 2000-2005. Texas cities are indicated in red.

Conclusions

Solar radiation was the only climate variable that was found to be significantly related to the timing of peak influenza activity. The observed negative association with solar radiation potentially offers a biological basis for the significant positive relationship with latitude. Though our period of study is relatively short, our results concerning the importance of solar radiation as a predictor of epidemic timing in the context of surveillance are promising.

References

[1] Finkelman BS et al. 2007. Global Patterns in Seasonal Activity of Influenza A/H3N2, A/H1N1, and B from 1997 to 2005: Viral Coexistence and Latitudinal Gradients. *PLoS One*; 12: 1:10, e1296

[2] Cannell JJ et al. 2006 Epidemic influenza and vitamin D. Epidemiol Infect 134: 1129-1140.

[3] Carrillo-Vico A et al. 2005.A Review of the Multiple Actions of Melatonin on the Immune System. *Endocrine*; 27: 189-200

[4] Lowen AC, Mubareka S, Steel J, Palese P. 2007. Influenza Virus Transmission Is Dependent on Relative Humidity and Temperature. PLoS Pathogens 3 e151.

[5] Polozov IV, Bezrukov L, Gawrisch K, Zimmerberg J. 2007. Progressive ordering with decreasing temperature of phospholipids of influenza virus. Nat Chem Biol 4: 248-255.

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