Spatio-temporal patterns of smallpox epidemics in the United States from 1915 to 1950

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Prior to its full eradication in 1980 Smallpox was a highly infectious disease, with a mortality rate as high as 50% in some countries. In the US, historical records report a first introduction in Florida, in the 1890s, after which the epidemics spread around the country, until its official elimination in 1952.

Despite its historic ubiquity across the globe and concerns about bioterrorism, the dynamics of smallpox spread have not been extensively studied, with the exception of the United Kingdom.

Here we use a large dataset of historical smallpox cases, complied under Project Tycho, to assess the presence of spatio-temporal patterns in US smallpox outbreaks. We applied continuous wavelet transform and empirical mode decomposition analyses to time-series of historical smallpox cases aggregated at the county level from 1915 to 1950.

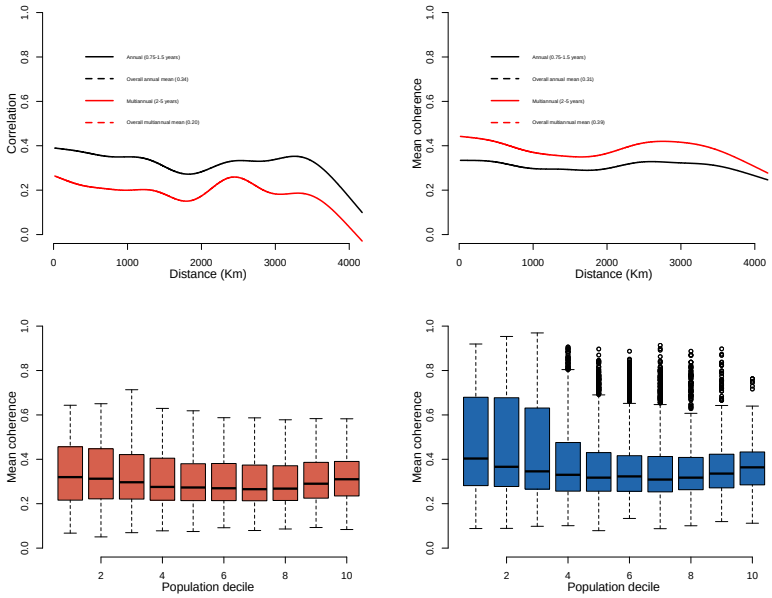

Figure 1 Synchrony in timing of smallpox cases by distance (Km) and by population deciles. Correlation is the pearson correlation coefficient between the wavelet coefficients of the county-pairs. Dashed lines refer to the overall mean correlation across all pairs. Coherence refers to the strength in frequency and timing of normalized bi-weekly cases between two counties. Population categories are the deciles of the population product of two counties. Red population colors refer to the annual and blue refers to the multi-annual periods.

We observed an overall level of synchronization of major smallpox epidemics across different US counties, and in particular during 1918, 1919, and 1921. Furthermore, we observed spatial dependence of coherence between epidemics in counties up to 2000 Km from one another. On average, the coherence of annual epidemics did not vary as population size changed. County-pairs with the smallest and largest populations had higher average coherence of major multiannual epidemics, though these differences were not significant. Further examination of the mechanisms driving observed epidemic synchrony is ongoing, and will include an examination of climatic, demographic, and immunologic factors. Our analysis will hopefully lead to a better understanding of smallpox transmission at smaller spatial scales, which will aid in future drug development and bioterrorism intervention and prevention strategies.