The spatial and temporal anatomy of seasonal influenza in the United States, 1972–2007

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Objective

To study the seasonality of influenza in the United States between 1972 and 2007 through the evaluation of the timing, velocity and spatial spread of annual epidemic cycles.

Introduction

Seasonality has a major effect on the spatial and temporal (i.e., spatiotemporal) dynamics of natural systems and their populations (1). Although the seasonality of influenza in temperate countries is widely recognized, interregional spread of influenza in the United States has not been well characterized.

Methods

We used weekly pneumonia and influenza (P&I) mortality data from the National Vital Statistics System (NVSS) (1972–1988) and the Centers for Disease Control and Prevention (CDC) 121 Cities Mortality Reporting System (1996–2008) to construct weekly time series of P&I mortality for each year and Census Bureau Division. The timing of each seasonal wave was determined by identifying a significant increase and subsequent decrease in P&I mortality plus a lead-in and a lead-out week. Average time to death ([Σ[(t)(nt)]]/N; where N = total P&I deaths for all weekly periods in the season, t = week of season (e.g., 1, 2, etc.), and nt = total P&I deaths for week t) was used to determine the timing and velocity of each seasonal influenza wave. Ordinary least squares regression was used to develop trend lines and spread vectors for annual influenza epidemics in order to determine the directionality of annual influenza waves. Average time to national spread, average time to national peak P&I mortality and average P&I mortality were also determined and compared between influenza subtypes.

Results

For the years 1972–1988 and 1996–2008, annual influenza epidemics needed an average of 7.9 weeks to spread across the country and lasted an average of 22 weeks. Seasons where H3N2 was the dominant influenza subtype (N = 13) were, on average, significantly shorter (20.3 vs. 26.7 weeks $p = 0.0049$) and spread quicker (time to death: 10.3 weeks vs. 13.8 weeks, $p = 0.0053$) than seasons with H1N1 as the dominant subtype (N = 3). There was also a significant difference in the average time to national spread between H3N2-dominant seasons and H1N1-dominant seasons (6.1 vs. 13 weeks, $p = 0.0253$) (Table 1). Moreover, an average seasonal traveling wave of influenza began in the East North Central region then took two routes: (1) eastward then southward along the Atlantic coast and (2) westward to the Pacific coast.

Conclusions

Preliminary results of this analysis suggest that certain temporal patterns of influenza seasons vary by influenza subtype. Future analyses will focus on determining the temporal characteristics for influenza seasons between 1989 and 1996 (and for seasons between 1996 and 2007, using complete NVSS mortality sets) and assessing the intercounty spread of epidemic influenza. Accurately identifying spatiotemporal patterns could improve epidemic prediction and prevention as well as aid the creation of efficient containment policies for pandemic influenza (2). This analysis will aid public health in developing more effective and efficient strategies to decrease morbidity and mortality associated with seasonal influenza in the United States.

Keywords

Pandemic preparedness; spatial dynamics; geographic synchrony

References

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Table 1. ANOVA analysis of the means of seasonal parameters of epidemic influenza in the United States, 1972–1988 and 1996–2008, by dominant circulating influenza subtype

Influenza subtype (No. seasons)	*Total seasonal P&I mortality*	*Average time to death†*	*Season length†*	*Time to national spread†*	*Time to peak P&I mortality*
B (3)	29344	10.5	20	8	7
B/H1N1 (4)	26784	13.7	26.5	10	7.8
B/H3N2 (4)	22285	11.7	22.5	9	10.8
H1N1 (3)	28408	13.8	26.7	13	10.7
H1N1/H3N2 (1)	26937	8.3	16	3	7
H3N2 (13)	26335	10.3	20.3	6.1	8.1

†$p < 0.05$.

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