Respiratory viruses' effect on all-cause mortality: Winter and summer pseudoseasonal life expectancy in the United States

Preliminary version; please contact the authors for latest version before citing. Comments appreciated.

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Short Abstract

In temperate climates, mortality is seasonal with a winter-dominant pattern, due in part to cause-specific processes such as pneumonia and influenza. However, cardiac causes — which are the leading cause of death in the United States — are also winter-seasonal although it is not clear why. Interactions between circulating respiratory viruses (e.g., influenza, parainfluenza) and cardiac conditions have been suggested as a cause of winter-dominant mortality patterns. We propose and implement a way to estimate an upper bound on the magnitude of virus-attributable mortality. We calculate 'pseudo-seasonal' life expectancy, dividing the year into two six-month spans, one encompassing winter the other summer. During the summer when the circulation of respiratory viruses is drastically reduced, life expectancy is about one year longer. This suggests that even if viruses cause excess winter cardiac mortality, the population-level mortality reduction of (for instance) a perfect influenza vaccine would be much more modest than is often recognized.

Background

Mortality in temperate climates is highly seasonal, with winter peaks and summer troughs (Rosenberg 1966; Land and Cantor 1983; Mackenbach et al. 1992; Rau 2006). Heat wave-associated summer deaths are ephemeral interruptions of this overall cyclic pattern (e.g. Valleron and Boumendil 2004; Toulemon and Barbieri 2008). Respiratory and circulatory causes dominate the seasonal effects, with cancer being negligibly seasonal (Crombie et al., 1995); heat waves have a different composition by cause (Basagaña et al., 2011). Causation is complex and not fully resolved (Cheng, 2005). Temperature is thought to play a role (Mercer, 2003). However, Wilkinson et al. (2004) report no relationship between winter excess mortality and socioeconomic status in Britain, indicating that mortality seasonality is more complex than being a direct function of insufficient winter heating associated with poverty. Hypovitaminosis D is also thought to play a role in health, including in fatal diseases (Holick, 2007), and is seasonal with winter peaks (Kasahara et al., 2013).

The extent to which increased transmission of respiratory viruses during the winter (Glezen et al. 1987; colloquially, 'flu season') is responsible for the overall winter increase in mortality is debated (CITE). There seems to be causal nexuses between viral activity and adverse cardoiovascular events (Udell et al., 2013). The underlying causal role of astronomical season in the flu season is is also debated, with the coincidence of the school year (cite) and dynamic resonance (Dushoff et al., 2004) being alternate hypotheses.

Methods

From the mortality detail files of the National Center for Health Statistics (NCHS 2012), we extracted data on every death in the United States, January 1959 to December 2010[1]. The data were then aggregated by month, sex, and 22 age groups (0, 1–4, 5–9, ..., 95–99, $\geq$100), and binned into six-month pseudoseasons. These periods are pseudowinter (November through April) and pseudosummer (May through October). The logic for the boundary months is as discussed above. Note that pseudoseasons do not nest into calendar years. The data begin with pseudosummer 1959 and end with pseudosummer 2010. There are 52 pseudosummers in our data set and 51 pseudowinters (1960–61 to 2009–10). Data for January through April 1959 were discarded since using these data for pseudowinter 1959–60 would be biased due to the omission of November and December 1958, because the omitted months have much milder mortality. Similarly, November and December 2010 were discarded.

We constructed denominator data using age- and sex-specific calendar-year exposure data from the Human Mortality Database (2012). Because of the non-nesting property of pseudoseasons in calendar years, we interpolated to months, adjusting for days per month and leap years, and then re-aggregated the pseudoseasonal exposure. We calculated sex- and age-specific death reates for each pseudoseason using these exposures in the denominator and the pseudoseasonal death counts in the numerator. From from these death rates, sex specific life tables were calculated using standard techniques (Keyfitz, 1970; Preston and Guillot, 2001). All the pseudoseasonal life expectancies used herein come from those life tables.

Results

Figure 1 presents our results as four time series: pseudowinter (solid) and pseudosummer (dashed), for both males (blue) and females (red). The irregular gray tubes enveloping each sex are not confidence intervals per se,

[1]Prior to 1959, digitized mortality data are not available for the United States that are simultaneously disaggreatable by age, sex, and month. The most-recently released data are for calendar year 2010.

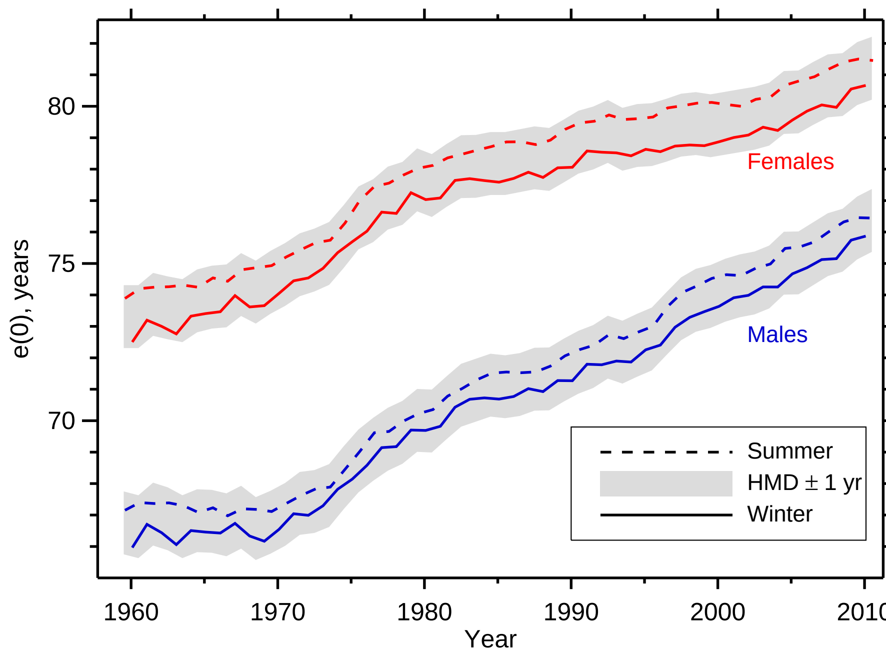

Figure 1: Life expectancy time series by sex and by pseudoseason.

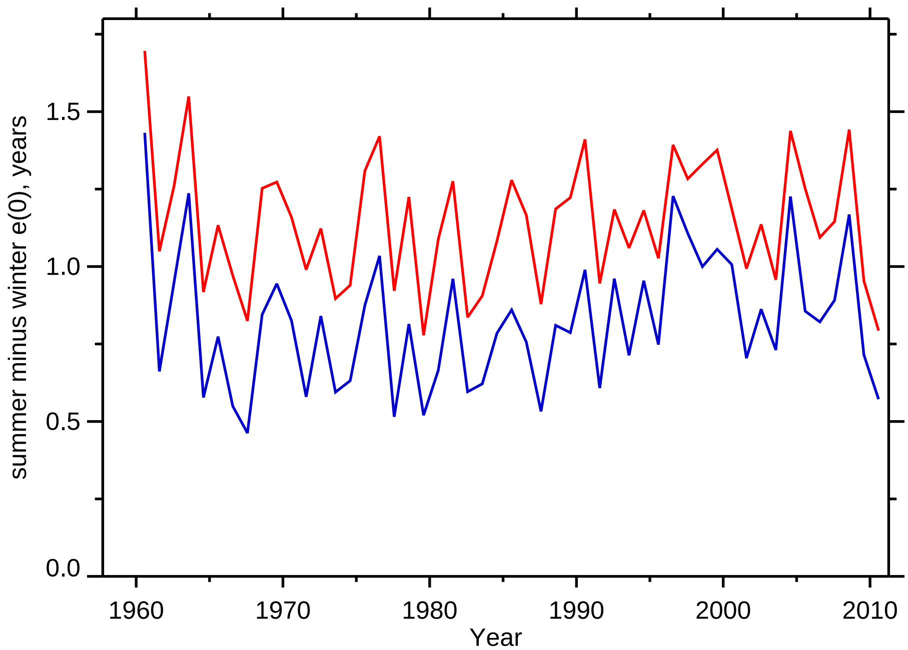

Figure 2: Summer advantage over winter in pseudoseasonal life expectancy, females (upper series) and males (lower series).

but 2-year wide bands around calendar-year life expectancy from the Human Mortality Database (HMD). These gray tubes are illustrative: since the top of the gray band represents the calendar-year data +1, the summer pseudoseasonal life expectancy is never greater than one year above the neighboring calendar-year life expectancy. Similarly, since the bottom of the gray band is the calendar-year data −1, it shows that winter pseudoseasonal life expectancy is always within one year of the neighboring calendar-year e(0). This provides a rough-and-ready estimate of the differece in the summer and winter mortality regimes. Moreover, using the HMD e(0) data as the center of the band provides an external check of our life expectancy calculations; it stands to reason that the calendar-year series should be quite close to the middle of our pseudoseasonal data, and they are.

Figure 2 shows the summer advantage over winter for males and females. This figure plots the difference between summers and their preceding winters, from the summer of 1960 minus the winter of 1959–60, to the summer of 2010 minus the winter of 2009–10. This plot has three important features. First, no secular time trend is evident. Second, the data are strongly negatively autocorrelated: declines are followed by increases, which are followed by declines. Third, in addition to higher life expectancy per se, women show a higher summer-winter difference (1.14 years of e(0) on average, versus 0.82 years for males). These features will be interpreted below.

Discussion & Conclusion

Our findings show that the overall effect of the winter increase in mortality is quite modest: just over one year of life expectancy for women and just under one year for men. To put this in context using the most-recent HMD whole-year life expectancy data for the USA, living in the winter (so to say) would be like turning back the clock from 2010 to 2006 for both sexes. In other words, the life expectancy gains from 2006 to 2010 are about the same magnitude as the average summer-winter difference seen in figure 2. If we could wave a magic wand, eradicating influenza, respiratory syntictal virus, and other pathogens which circulate in the winter, and, what is more, making the winter pattern of cardiac mortality look like the summer pattern, this amazing feat would in fact only be equivalent to about four years' worth of temporal progress vis-à-vis mortality reduction.

The reason for this modest difference is easy to see, at least in retrospect. Simply focusing on the number of influenza-related deaths in the winter as well as the increase in cardiac-related mortality — and supposing that vaccination and other medical/public health measures could eliminate these deaths — ignores the fact of competing risks in the life table. Nowadays, most American mortality occurs above age 70, so a death (hypotheitcally) averted is still subject to high mortality rates ... etc etc cancer mortality not seasonal... RECTANGULARIZATION cite...

Cite Sheth et al. (1999) here

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