Seasonal dynamics of mortality in the United States from 1982 to 2013

Robbie Parks[α], **James Bennett**[α], **Kyle Foreman**[β], **Ralf Toumi**[γ], **Majid Ezzati**[α]

[α]MRC-PHE Centre for Environment and Health, Dept Epidemiology and Biostatistics, School of Public Health, Imperial College London

[β]Institute for Health Metrics and Evaluation, University of Washington, Seattle, USA

[γ]Space and Atmopheric Physics, Faculty of Natural Sciences, Department of Physics, Imperial College London

Background

- It has been hypothesised that a warmer world may lower winter mortality in temperate climates.
- There is however limited data to characterise the seasonality of mortality in relation to age, sex, and local climate, or to understand how it has changed over time.

Data and methods

- All deaths in the USA from 1982 to 2013 from the National Center for Health Statistics, with information on age, sex, state and county of residence, and month of death.
- Gridded four-times-daily estimates at a resolution of 80km to generate monthly population-weighted temperature by climate region.
- Wavelet analytical techniques to analyse the seasonality of mortality by age group and sex, nationally and by climate region.

Results

National wavelet analysis

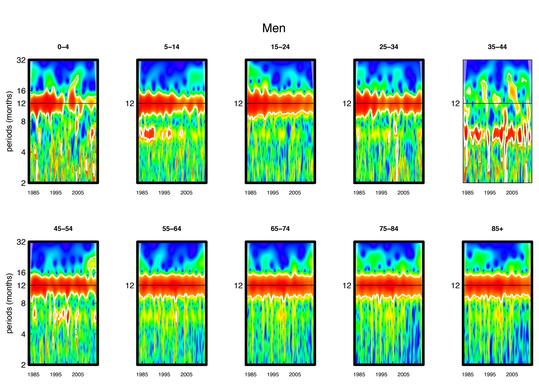

Figure 1: Wavelet power spectra for national time series data for 1982-2013, by age group for men. Wavelet power values increase from blue to red, with white contour lines indicating the 5% significance level against a white noise spectrum.

- All-cause male mortality had a statistically significant 12-month seasonality in all age groups except in ages 35-44 years, who displayed statistically significant periodicity at 6 months (Figure 1).
- In females, there was no significant 12-month seasonality in ages 5 to 34 years (Figure 2); girls aged 5-14 years exhibited periodicity at 6 months for most of the analysis period.
- While seasonality persisted throughout the entire analysis period in older ages, it largely disappeared after late 1990s in children aged 0-4 years in both sexes and in women aged 15-24 years.

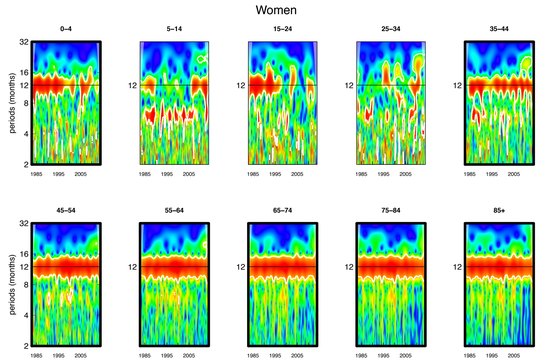

Figure 2: Wavelet power spectra for national time series data for 1982-2013, by age group for women.

National mean timing of seasonal mortality

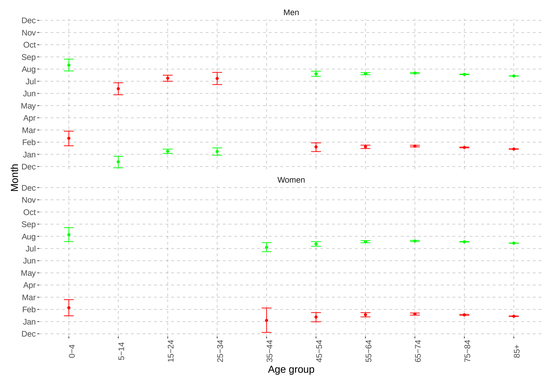

Figure 3: Mean timing of national maximum and minimum all-cause mortality, by sex and age group for 1982-2013. Red dots indicate the month of maximum mortality, and green dots that of minimum mortality. Vertical segments represent 95% confidence intervals. Only age-sex groups with statistically significant 12-month seasonality are included.

- Death rates in men aged ≥45 years and women aged ≥35 years peaked in January and February, and were lowest in July and August (Figure 3).
- Children younger than five years of age mortality was highest in February and lowest in August.
- Peak and minimum of mortality in older boys and young men (ages 5-34 years) occurred in June/July and December/January.

Change in percent difference between max/min mortality over time

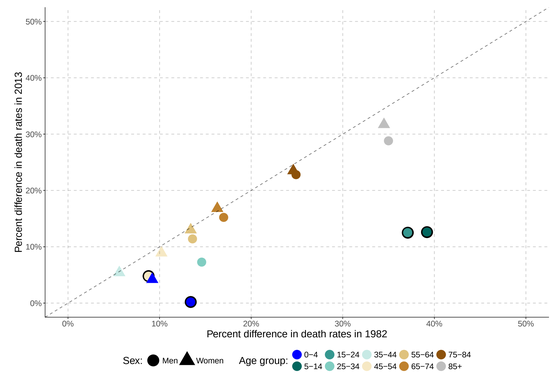

Figure 4: National percent difference in death rates between the maximum and minimum mortality months in 2013 versus 1982 by sex and age group. Age-sex groups with a statistically significant change at the 5% level are highlighted with a bold black outline.

- Declined by less than seven percentage points for people older than 45 years of age from 1982 to 2013 (Figure 4).
- Difference between peak (summer) and minimum (winter) declined significantly in younger ages, by nearly 25 percentage points in males aged 5-14 years and 15-24-years.
- Under five years of age, percent seasonal difference declined by a statistically-significant 13.2 percentage points (95% CI 8.1 to 18.2) for boys but only a statistically insignificant 5.0 percentage points (-12.0 to 2.0) for girls.

Subnational mean timing of seasonal mortality

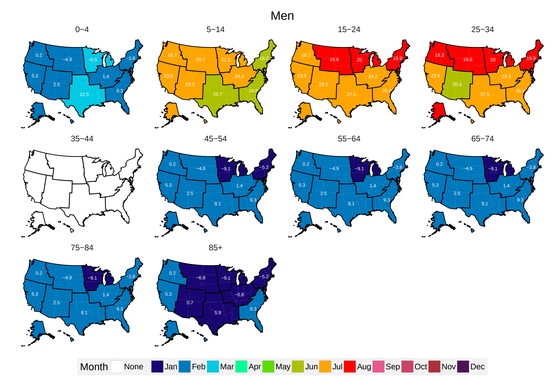

Figure 5: Mean timing of maximum all-cause mortality, by climate region and age group for males 1982-2013. Only age-sex groups with significant 12-month seasonality in the national analysis are included. Average temperatures (in degrees Celsius) are included in white for the corresponding month of maximum and minimum mortality for each climate region.

- Relative homogeneity of the timing of maximum mortality is evident (Figure 5), despite the large variation in temperatures that exist between climate regions during the same months.
- Similar homogeneity for females of all ages.

The relationship between percent difference between max/min mortality and temperature difference

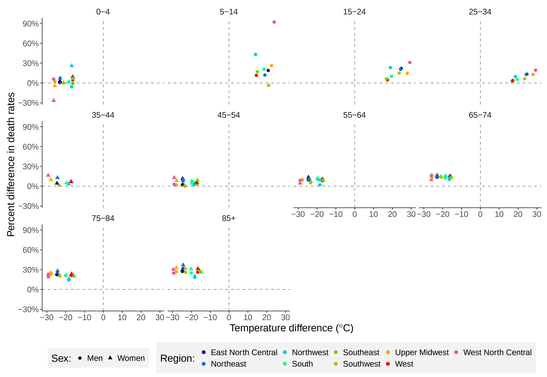

Figure 6: The relationship between percent difference in death rates and temperature difference between months in which mortality peaks versus troughs across climate regions, by sex and age group in 2013. Only age-sex groups with significant 12-month seasonality in the national analysis are included.

- Above 45 years of age, there is little inter-region variation in the percent seasonal difference, despite the large variation in temperature difference between the peak and minimum months (Figure 6).
- The absence of association between the magnitude of mortality seasonality and seasonal temperature difference indicates that different regions in the USA are similarly adapted to temperature seasonality.

Summary

- Comprehensive analysis of seasonality over three decades in relation to age, sex, and geography
- Analysing by these strata allowed us to identify distinct seasonal behaviours in relation to age and sex.

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