Socioeconomic differences in seasonal mortality in the United States

Extended Abstract

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September 16, 2010

Abstract

We analyze whether people from lower socioeconomic groups do not only suffer from higher mortality but are also exposed to higher seasonal fluctuations in mortality. Our hypothesis is that people of lower socioeconomic status might be more exposed to risk factors for winter excess mortality like poor housing conditions.
Our analysis is based on individual death records from 1989 until 2006 published by the NCHS. The actual analysis employs a newly developed method to model seasonal fluctuations simultaneously over age and time. In our preliminary estimations we restricted ourselves to deaths from heart diseases and respiratory diseases which represent about 40% of the 41.9 millions deaths which occurred in the US between 1989 and 2006. Contrasting seasonality in deaths of people with "high" and "low" education in our preliminary analysis, we could not detect any noteworthy differences in seasonality between the socioeconomic groups.

1 Introduction

Few findings in mortality research are as well supported by empirical studies across age, calendar time and country as socioeconomic-mortality differentials and seasonal fluctuations in mortality:

Socioeconomic Mortality Differentials: Irrespective of the method how socioeconomic status (SES) is measured (e.g. education, occupation, income), there is an inverse relationship between SES and mortality. People of higher SES tend to have lower mortality.[1]

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[1]Please see the appendix for a list of references.

Seasonal Fluctuations in Mortality: With the exception of Iceland, industrialized countries feature higher mortality in winter than in summer. This is mainly due to the increased risk of dying from circulatory diseases such as myocardial infarction disease or stroke and from respiratory diseases, most notably pneumonia.[2]

However, the question how socio-economic status affects seasonality in mortality is still unanswered (Rau, 2005). It can be argued, for instance, that people of lower SES might be more exposed to classical risk factors such as poor housing conditions, more time spent outdoors, or worse clothing. This should result in higher seasonal fluctuations. Few studies, though, argue that lower social groups are, indeed, disadvantaged with respect to seasonal mortality (e.g. Donaldson and Keatinge, 2003; Healy, 2003), others found no social gradient (e.g. Lawlor et al., 2002, 2000; Rau, 2004; Shah and Peacock, 1999; Wilkinson et al., 2004).

Our aim is to analyze whether we can detect support for the hypothesis that people of lower SES suffer from higher seasonal fluctuations in mortality in the United States. We argue that our analysis of individual level data might give more insight that several previous studies which focused solely on aggregate level data (e.g. area deprivation score). Furthermore, the United States is not as egalitarian as Denmark, a country where no seasonality differences by SES were found Rau (2004, 2007). Hence, we expect that it is more likely to detect socio-economic differences in seasonality of mortality in the US than in other previously analyzed countries.

In this extended abstract, we restrict our analysis to two major causes of death: heart diseases and respiratory diseases.

2 Data & Method

2.1 Data

We are using the "Vital Statistics NCHS's Multiple Cause of Death Data". These data list each single death in the United States as an individual record together with a large set of additional information about the death, including sex, age at death, month of death, year of death, ... They are available since 1959. However, we start our analysis only in 1989, the first year when education, our indicator for socio-economic status, has become available. The last year of available data is 2006. The data are freely available on the webpage of the National Bureau of Economic Research at `http://www.nber.org/data/vital-statistics-mortality-data-multiple-cause-of-death.html`. Education is given in number of years attended at school. For this extended abstract, we restricted ourselves to two categories: "low education" (8 years of school) and "high education" (at least 13 years of school.

The numbers of death we are analyzing is not the raw number one would get from the data but the number of deaths one would expect if each month had the same duration of

[2] Please see the appendix for a list of references.

30 days.

Table 1 gives an overview of the absolute and relative frequencies of deaths analyzed by us for the two causes of death. Although we do not analyze the majority of deaths in this extended abstract, heart diseases and respiratory diseases account for 31.14% and 9.43%, respectively, out of the more than 41 million deaths which have been recorded during the observation period from 1989 until 2006. Differences in the proportions between the sexes are rather negligible.

Table 1: Absolute (Unadjusted) and Relative Frequencies (in %) of Numbers of Deaths from Heart Diseases and from Respiratory Diseases for Women and Men in the United States, Aged 0–100 Years, from 1989–2006

Cause	Women		Men		Total	
	absolute	%	absolute	%	absolute	%
Heart Diseases	6,642,782	31.79	6,406,439	30.48	13,049,221	31.14
Respiratory Diseases	2,010,931	9.62	1,941,552	9.24	3,952,483	9.43
Rest	12,240,370	58.58	12,667,519	60.28	24,907,889	59.43
All Causes	20,894,083	100.00	21,015,510	100.00	41,909,593	100.00

2.2 Method

In the past, we have developed new statistical methods to overcome two problems we have encountered with standard procedures for seasonality: First, our methods is not restricted to a fixed seasonal pattern; we allow seasonality to change. Secondly, we model seasonal mortality simultaneously over age *and* time (Eilers et al., 2008; Marx et al., 2010).

Description of the Model Using a log-link, our modulation model estimates the mean ($\mu_{a,t}$) of death counts, $y_{a,t}$, over age a and time t which are assumed to be independent and follow a Poisson distribution:

$$\log \mu_{a,t} = v_{a,t} + f_{a,t} \sin\left(\frac{2\pi}{12}t\right) + g_{a,t} \cos\left(\frac{2\pi}{12}t\right) \tag{1}$$

The terms to be estimated, $v_{a,t}$, $f_{a,t}$, and $g_{a,t}$ are expected to change smoothly over age and time; The overall trend is fitted by $v_{a,t}$. It captures changes in the actual risk of mortality as well as changes in the exposures. The seasonal fluctuations are estimated by $f_{a,t}$ and $g_{a,t}$. Hence, our model follows the classical approach of seasonally adjusting time-series by decomposing the data into the long term trend, the seasonal component (the "signals"), and the irregular component (the "noise") (Shiskin, 1968).[3]
Details about the actual estimation and possible extensions, such as the inclusion of exposures into the model, are given in Eilers et al. (2008).

[3]Long term cycles would be captured in the trend component of our model.

Using basic trigonometric transformations, our estimated surfaces f and g allow us to obtain the amplitude of seasonality ("the height" of the fluctuations) and the phase, i.e. at which day of the year does mortality reaches its maximum.

3 Results

Figures 1 and 2 show the typical output from our estimations, in this case deaths from heart diseases for women with high education, aged 50 to 90 years during the years 1989–2006. The left panel in Figure 1 displays the input data. It can be read like a map: Blue colors denote low numbers of death ("sea level") whereas yellow and red colors indicate higher numbers of death ("mountains"). Despite the slightly different scale in the right panel, one can easily see that our procedure models the distribution of deaths across age and time very well. More interesting for our application is the seasonal component, though. The amplitude is depicted in the left panel of Figure 2. As other studies have shown, seasonality increases with age, reflecting the decreasing ability to withstand environmental stress at advanced ages. Besides this age effect, period effects can be detected, too: In 1991, 1996, 2000, and 2004, the seaonal amplitude shows higher values at virtually all ages. The right panel shows when deaths peak during the year. The yellow color indicates that the highest number of deaths is typically recorded approximately between days 40 to 50, i.e. in the middle of February.

To answer our reseach question, i.e. whether mortality fluctuates larger for people from lower than from higher socio-economic groups, we have chosen to select only a single age from the estimated surfaces. Figures 3–6 (pages 13–16) show the seasonal component for women and men who died from heart diseases (Figures 3 & 4, pages 13–14) and from respiratory diseases (Figures 5 & 6, pages 15–16).

Our results support previous findings from other countries which did not find socio-economic differences in seasonality of mortality. For deaths from respiratory diseases among men, we detect the expected tendency (Fig. 6). The blue curve typically exceeds the red curve, but only by a small margin. For deaths from respiratory diseases for women and for deaths from heart diseases for both sexes, we can not find any support for our hypothesis.

A Appendix

Literature for Socioeconomic Mortality Differentials (Selection)

Davey Smith et al. (1990, 1998); Doblhammer et al. (2005); Elo et al. (2006); Goldman (2001); Huisman et al. (2005); Kitagawa and Hauser (1973); Kunst (1997); Kunst et al. (2004); Mackenbach et al. (2003, 1999); Martikainen et al. (2001); Pappas et al. (1993); Rau et al. (2008); Shkolnikov et al. (2006); Valkonen (1989, 1999, 2006); Valkonen et al. (2000).

Literature for Seasonal Fluctuations in Mortality

Cordioli et al. (2000); Curwen and Devis (1988); Donaldson and Keatinge (2002); Donaldson et al. (1998); Douglas et al. (1991); Eng and Mercer (2000); Eurowinter Group (1997, 2000); Feinstein (2002); Gemmell et al. (1999, 2000); Grech et al. (2001); Healy (2003); Hernández and García-Moro (1987); Johnson and Griffiths (2003); Keatinge (1986, 1998); Keatinge et al. (1989); Keatinge and Donaldson (2001); Kunst et al. (1990); Lotufo (1999); Mackenbach et al. (1992); McDowall (1981); McKee (1989); McKee et al. (1998); Näyhä (2000); Paulozzi (1981); Rau and Doblhammer (2003); Rosenwaike (1966); Sakamoto-Momiyama (1977, 1978); Seretakis et al. (1997); Seto et al. (1998); Shah and Peacock (1999); Sheth et al. (1999); van Rossum et al. (2001); Wilkinson et al. (2004)

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Figure 1: Deaths from Heart Diseases for Women with High Education in the United States from 1989–2006, Aged 50–90 Years. Left Panel: Raw data, $y_{a,t}$; Right Panel: Fit $\hat{y}_{a,t} = \mu_{a,t}$

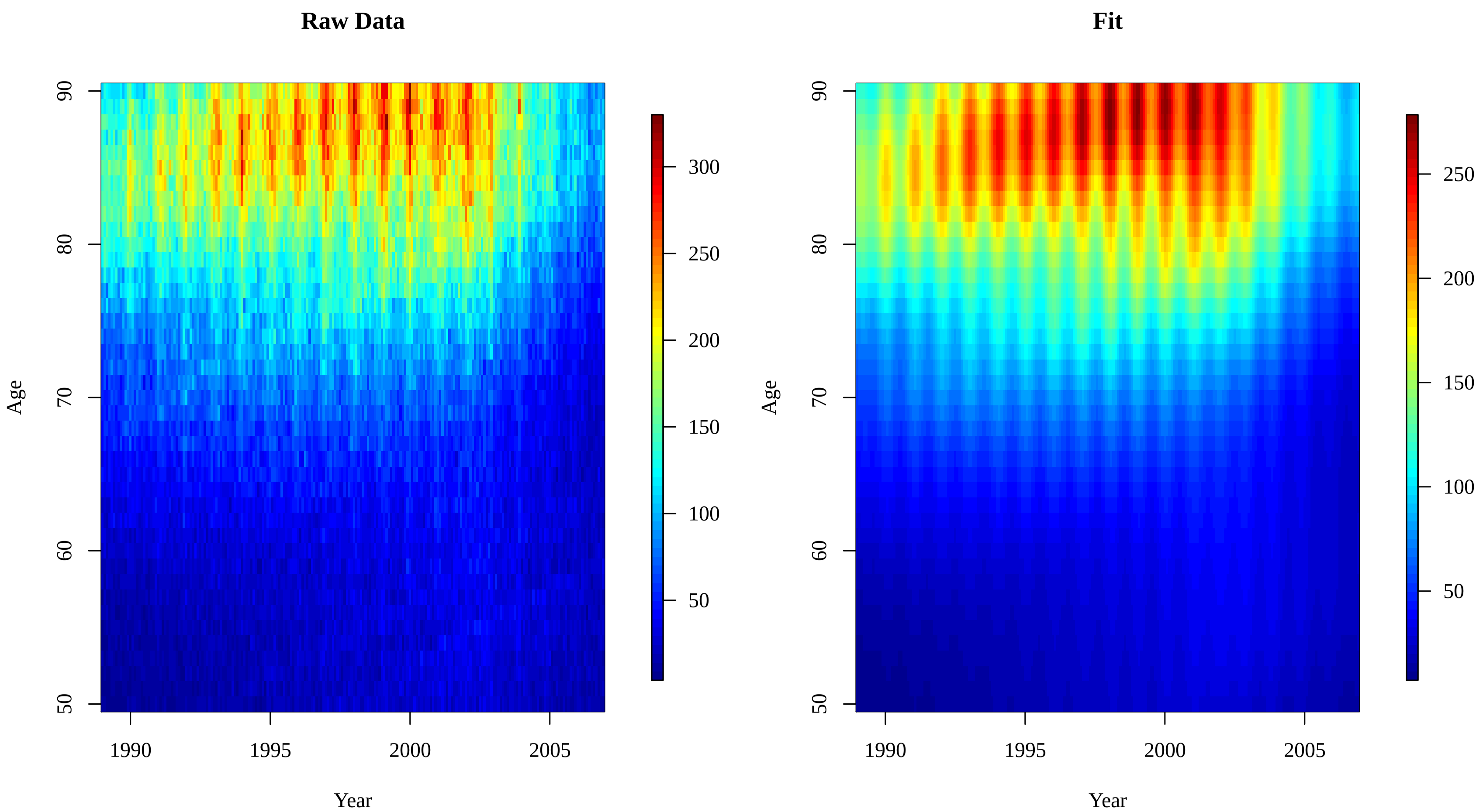

Figure 2: Seasonal Component for Deaths from Heart Diseases for Women with High Education in the United States from 1989–2006, Aged 50–90 Years. Left Panel: Amplitude; Right Panel: Phase

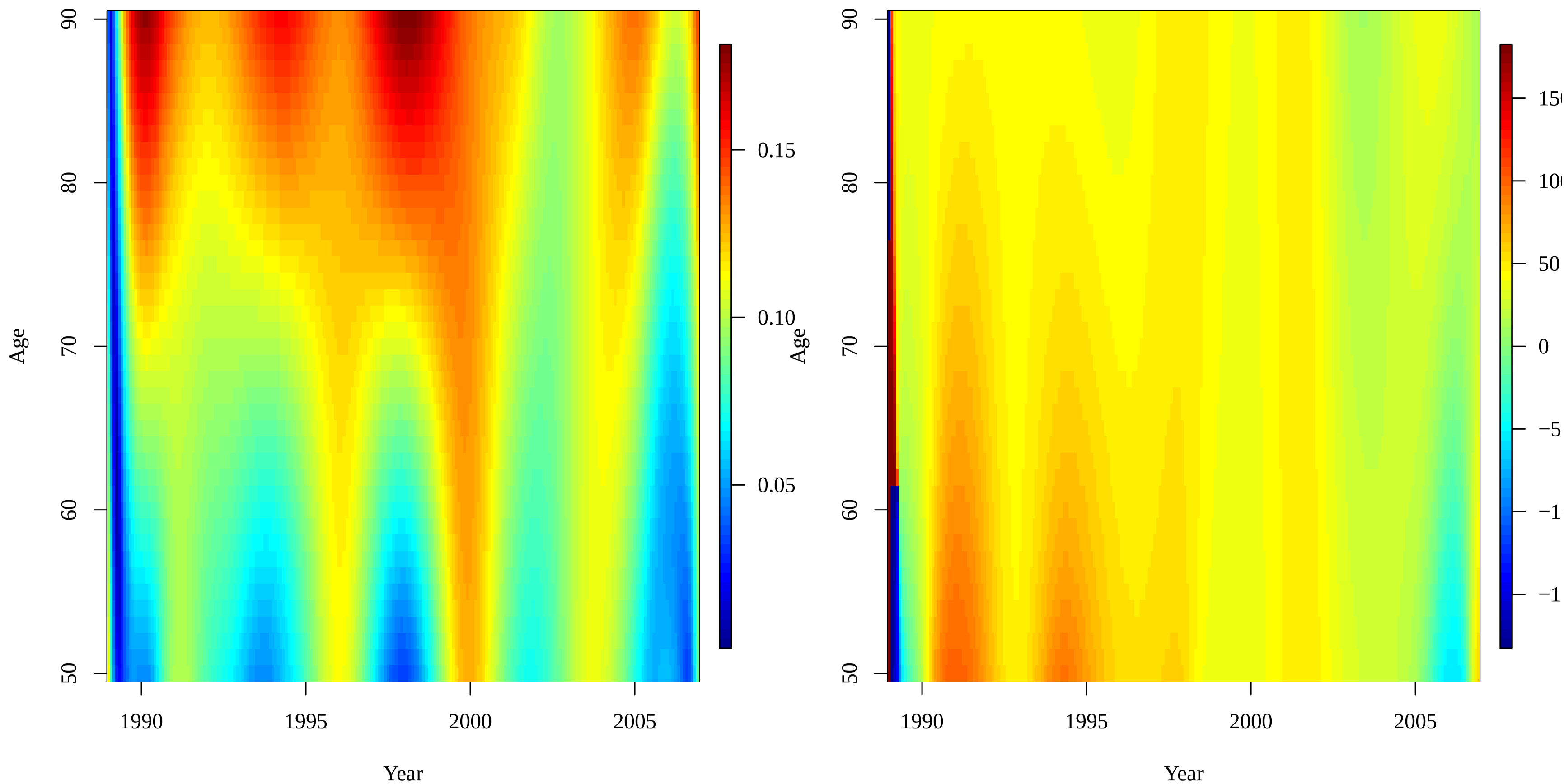

Figure 3: Seasonal Component for Deaths from Heart Diseases for Women, Aged 70 Years, with High and Low Education in the United States from 1989–2006.

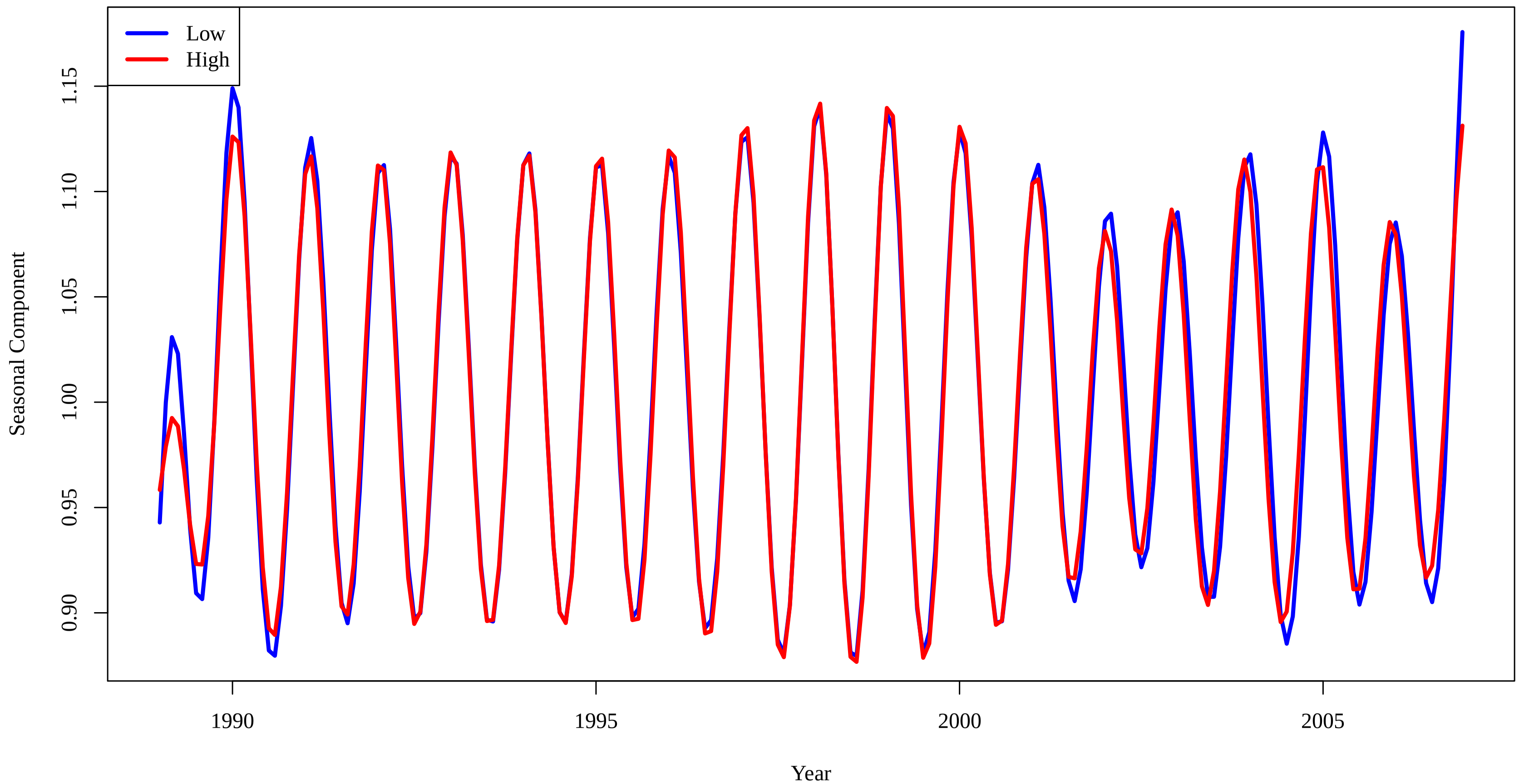

Figure 4: Seasonal Component for Deaths from Heart Diseases for Men, Aged 70 Years, with High and Low Education in the United States from 1989–2006.

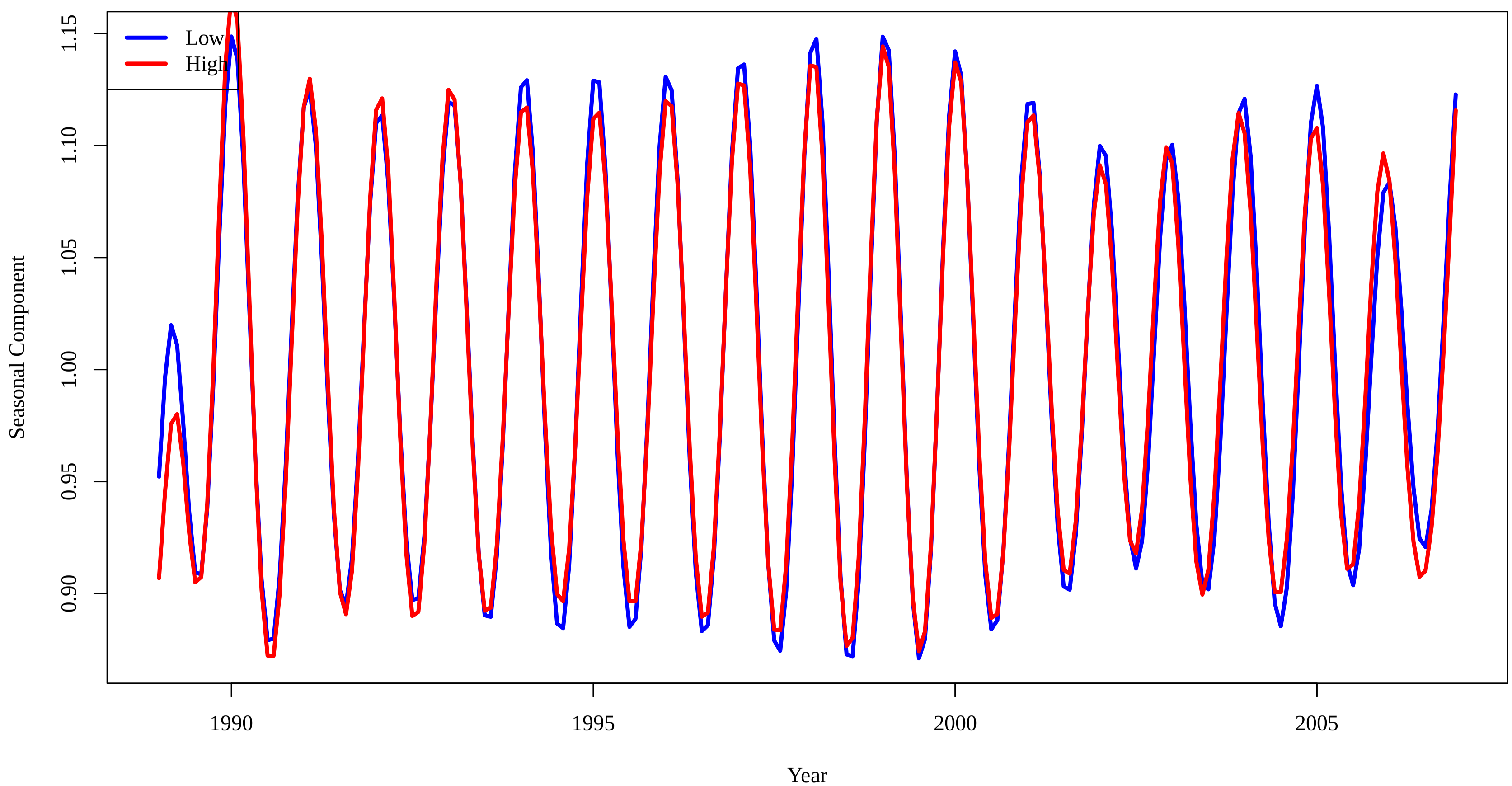

Figure 5: Seasonal Component for Deaths from Respiratory Diseases for Women, Aged 70 Years, with High and Low Education in the United States from 1989–2006.

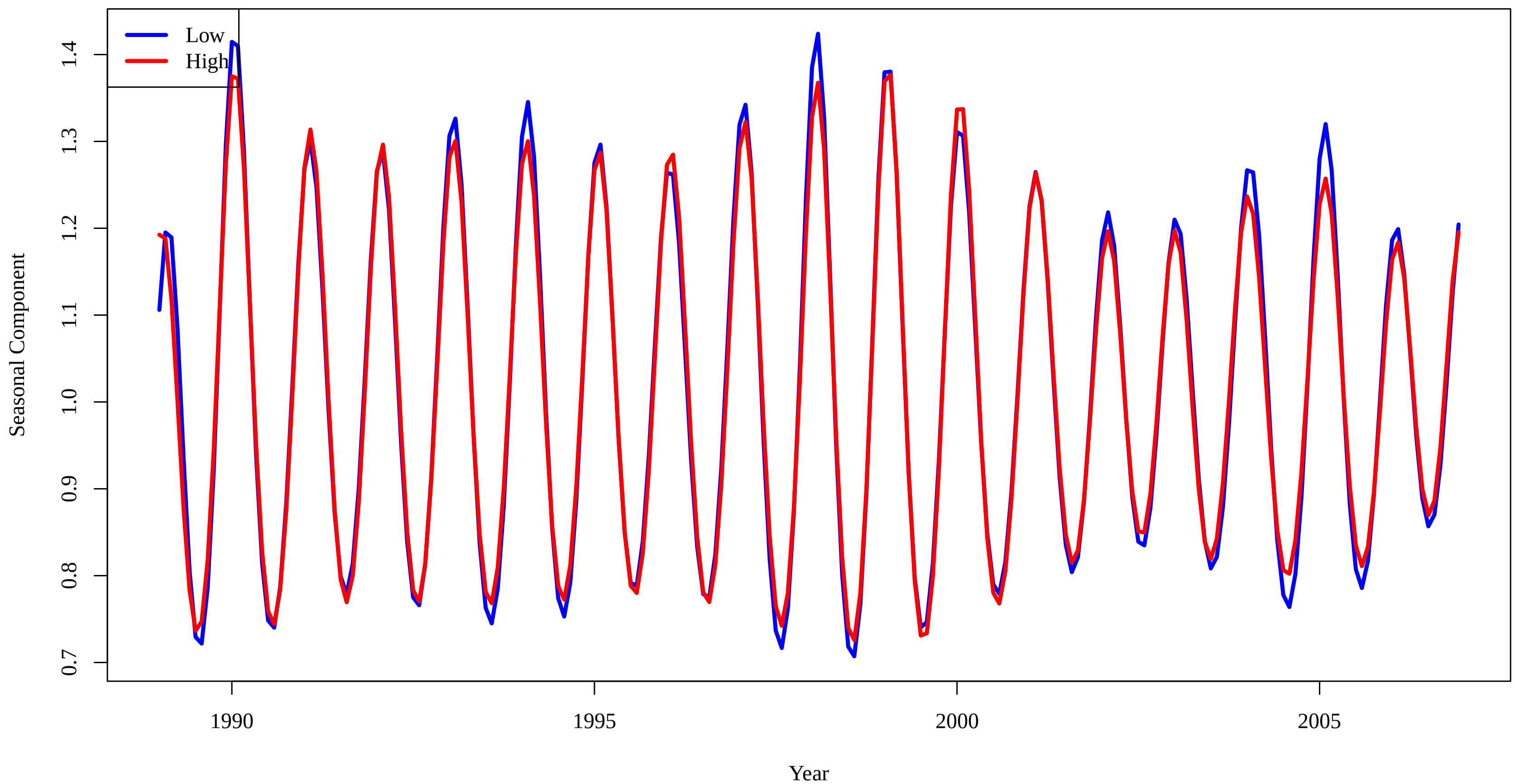

Figure 6: Seasonal Component for Deaths from Respiratory Diseases for Men, Aged 70 Years, with High and Low Education in the United States from 1989–2006.