4 Differences in Life Span by Month of Birth in the United States

The most important criticism about research on early-life environment and later-life health and mortality is concerned with how this research is interpreted (for an overview see Kuh & Davey Smith 1993). It has been argued that the strong correlation between early environment and adult mortality may simply be an effect of continued deprivation over the whole life course rather than of factors that act early in life (Ben-Shlomo & Davey Smith 1991).

This study uses month of birth as an indicator for early-life circumstances. The previous chapter provided evidence that the month of birth does not have any further life-course interpretations that affect mortality. The comparison of the pattern for people born in the Northern Hemisphere to those born in the Southern Hemisphere suggests that the effect of the month of birth on the life span is related to the seasons of the year. In both hemispheres, the remaining life expectancy after age 50 is lower for people born in the spring than for those born in the autumn. Thus, in the Northern Hemisphere the pattern is a mirror image of the Southern Hemisphere's pattern.

Furthermore, the previous chapter showed that a significant positive correlation exists between infant mortality in the first year of life by month of birth and mean age at death by month of birth. This led to the conclusion that it is debilitation rather than selection that leads to the differences in life span by month of birth.

The aim of this chapter is to gain deeper insights into the mechanisms that cause the differences in life span by month of birth by using information about the social, demographic, and geographic characteristics of the decedents. It explores whether the differences vary with educational background, marital status, region of birth, race, and sex on the basis of 15.6 million US death certificates for the years 1989 to 1997.

One would expect that the differences depend on social factors: they should increase with lower education and they should be larger for African-Americans than for whites. Education is largely heritable between generations and low education can thus be considered as an indicator for poor living circumstances of the decedent's parents and therefore also of the decedent's first period of life. Negative seasonal factors such as insufficient nutrition or infectious disease are more common and also more harmful under poor living circumstances than under more prosperous ones. The same argument holds for African-Americans and whites.

Evidence exists that marital status is partly determined by health selection into marriage (Goldman, Lord & Hu 1993) and that the never-married are frailer than the ever-married population (Goldman & Hu 1993). Differences in life span by month of birth should therefore be larger among the never-married than among the ever-married.

The information about state of birth allows to test four hypotheses that have been put forward to explain the month-of-birth effect. First, the state of birth provides information about the approximate latitude of birth and thus the seasonal differences in the hours of daylight. It has been shown that the seasonal changes in the hours of daylight influence the human neuroendocrine functions (Wehr 1998). Several researchers have postulated that the winter-spring birth excess observed in schizophrenia and bi-polar disorders might be caused by variations in internal chemistry or neural development brought about by seasonal variations in light (Turnquist 1993, Quested 1991, Morgan 1978, Jongbloet 1975, Pallast et al. 1994). If the effect of month of birth on mortality later in life is due to seasonal differences in daylight, then this effect should be correlated with latitude and should be smaller in the southern part of the US than in the northern part.

Second, the state of birth provides information about the prevailing macro climate. According to the widely used Köppen classification (Köppen 1936), the United States consists of six major climatic zones. Regions between 30 and 60 degrees North latitude belong to the *humid continental climate* zone characterized by changeable weather, hot summers and cold winters. On the eastern side of the continent between 20 and 35 degrees North latitude, the *humid subtropical climate* prevails. This climate is characterized by uniform precipitation throughout the year with moist and hot summers and mild winters. The *mild-latitude steppe* and *desert climate* are found in the continental interior and include the tropical and subtropical steppe climates in the South. Temperature conditions are extremely variable, with the annual means decreasing and the annual range increasing to the North. In the higher latitudes, winters are severely cold with meager precipitation. In the South the tropical and subtropical steppe climate is located primarily on the periphery of true deserts. The *Mediterranean Climate* of Southern California features hot dry summers and cool wet winters. The *Marine west coast climate,* which extends between 35 and 60 degrees North latitude, is characterised by ample precipitation in all months, small annual temperature ranges, mild winters and moderate summers with rarely more than 20 degrees Celsius. This area is confined to a narrow coastal strip of the West Coast.

The magnitude of seasonal differences in temperature depend on the climate. Huntington (1938) was one of the first to formulate the hypothesis that temperature, in particular high temperature at the time of conception, causes the differences in life span by weakening the "germ plasma".

".....season of birth is related to length of life primarily, although perhaps not wholly, through the condition of the parents and hence of the germ plasma at the time of conception. This by no means excludes the hypothesis of a permanent depressive effect when a very young infant experiences undue heat or disease regardless of any selection through death". (p. 186)

More recent research has shown that the sperm quality of men who work outdoors decreases during periods of high temperature (Centola & Eberly 1999). Pasamanick (1986) proposed that hot summers were the cause of protein deficiency at the time of conception. As temperatures are generally highest in July/August, infants born in March and April should experience the lowest life expectancy. The peak-to-trough difference should be largest in regions with high summer temperatures.

The third hypothesis is that infectious disease causes the differences in life span by month of birth. The information about state of birth is linked to the burden of infectious diseases imposed by the climate. Climate influences the incidence of infectious diseases through temperature, humidity, and precipitation in the form of normal and severe rainfall, wind and ocean currents. Thus, the incidence of infectious disease is generally highly seasonal. *Vectorborne diseases* such as malaria and dengue fever were once common in the southern United States. The incidence of waterborne diseases, which account for as much as 80 percent of the annual mortality due to infectious diseases (Clark 1993), is correlated with warmer temperatures and flooding (Colwell 1996, Gueri, Gonzalea & Morin 1986). The transmission of infections via food in the form of viruses, bacteria, and protozoa causes significant illness. Campylobacteriosis is a common diarrhoeal disease of bacterial origin, which is generally acquired by drinking contaminated milk or water or by eating improperly cooked meat or fowl. There is a pronounced seasonality in its incidence since it normally occurs during the spring (Korlath et al. 1985). The incidence of other foodborne diseases, such as salmonella enteritidis (Shears & Wright 1985) and cyclospora cayetanenis (Madico et al. 1997), coincides with peak climatic temperatures. The seasonal variability of many respiratory diseases suggests the existence of a weather-related factor in the transmission of airborne diseases. The respiratory syncytial virus, which peaks in the autumn (Shears & Wright 1995), commonly causes bronchitis and mild upper-respiratory-tract infections that can result in severe, and even fatal lower tract problems, especially among infants.

The southern part of the US should have been an unhealthier environment for infants (when controlled for urban/rural residence, race and socioeconomic status) because of a higher incidence of infectious and parasitic disease and gastroenteritis. An increase in the peak-to-trough difference from North to South would thus suggest that infectious disease during childhood plays a major role in old-age mortality.

On the other hand, respiratory diseases, which are mainly caused early in life by seasonal virus infections, were spread more in the poorly ventilated conditions accompanying winters in the North[1] (Preston & Haines 1991).

The fourth hypothesis is that the nutrition of the mother during pregnancy and of the baby in the first year of life is the causal mechanism that underlies the month-of-birth pattern. Diet is the result of a complex interaction of social, economic, and environmental factors. At the beginning of the 20th century, large regional differences in diet existed in the US. What the different diets had in common was that they do not resemble contemporary US dietary patterns (Levenstein 1988, 1993). People ate meat – either fresh meat in the middle or upper classes, or salted meat among the poor – with potatoes or some other starchy staple. Other vegetables and fruits occupied only a small niche on the table. The first vitamin was only discovered in 1911; in the early 1900s nutritionists were actually even opposed to greens, which were thought to require more bodily energy for digestion than they provided (Dyson 2000). With the notable exception of the South, there is no indication that even the poorest workers suffered from insufficient quantities of food. The problem was rather the quality and the variety, especially during the winter and spring, when affordable supplies dried up. As mentioned above, there were large regional differences in diet. Diet was particularly poor in the rural South, where farmers – many of whom were tenant farmers – survived on the "three m's", that is, meat (salted pork), meal (mainly corn meal) and molasses. Sharecroppers moved too frequently to raise their own vegetables or livestock. As a result, milk and fresh meat, even fresh pork, were usually rarities on croppers' tables. The tenancy system discouraged the production of non-cash crops and tenants depended on the sale of flour, molasses, sugar and salt pork, which mainly came from the large meat factories in Chicago. In the

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[1] The text refers to New England, the Middle Atlantic, East North Central, and West North Central as the North; to the South Atlantic, East South Central and West South Central as the South; to the Mountain Region and Pacific as the West.

summertime, greens and berries could be gathered, but the hard work required during planting time in the spring and harvest time from August to December normally inhibited those endeavours, particularly in the cotton belt (Levenstein 1993). Contemporary dietary studies have shown that, particularly in winter and early spring, diets in the rural South lacked variety whereas better nutrition and a wider variety of foods was shown to exist in the urban South (Dirks & Duran 2001).

In summary, in the North and in urban areas people suffered from seasonal deficiencies in nutrients while in the rural South they experienced deficient nutrition during the whole year, with downright malnutrition in winter and early spring.

The effects of region, birth, race, and education are inherently confounded. There are two other confounding factors, namely, age and cohort. Chapter 6 will show that the differences in life span by month of birth are smaller in more recent cohorts and that they become smaller with age. Due to the cross-sectional nature of the US death records one cannot distinguish between age and cohort effects. However, the calculations are age-standardised when the data are analysed by univariate methods, and they control for the main effects of sex, education, race, and region on age at death used when multivariate methods are applied.

4.1 Data

This chapter is based on the publicly available Multiple Cause of Death Data for the years 1989 to 1997 from the National Center for Health Statistics (NCHS), to which the information about month of birth was added. This study consists of 15,596,952 death records for all black and white US-born decedents who died in the United States between 1989 and 1997. Table 4.1 gives an overview of the data regarding mean age at death and the proportion of the decedents that fall into the different categories of education, marriage status, race, and region of birth. Two educational groups are distinguished: the 5.3 million decedents with a basic education have less than a high school education or did not finish high school (up to eleven years of education); the 8.2 million decedents with a high education have at least finished high school. There is also a residual group of 2.2 million death records with an unknown educational level. The analysis is restricted to blacks and whites to guarantee that a sufficient number of deaths were given for each month of birth. The states of birth are grouped

Table 4.1. Number, proportion, and mean age at death of US decedents by region, sex, education, marital status, and race.

	Total	Mean age at death	%
Region of birth			
New England	928,642	77.10	0.06
Middle Atlantic	2,950,756	76.83	0.19
East North Central	2,900,962	77.05	0.19
West North Central	1,855,131	78.68	0.12
South Atlantic	2,409,504	75.34	0.15
East South Central	1,666,643	75.93	0.11
West South Central	1,839,805	76.12	0.12
Mountain	448,687	76.12	0.03
Pacific	579,369	74.87	0.04
Sex			
Males	7,665,738	74.27	0.49
Females	7,931,214	78.86	0.51
Race			
Whites	13,871,496	77.03	0.89
Blacks	1,725,456	73.20	0.11
Education			
Low (<12 years)	5,261,840	78.35	0.34
High (>=12 years)	8,164,552	75.43	0.52
Unknown	2,170,560	76.80	0.14
Marrital status			
Never married	1,046,611	75.15	0.07
Married	6,844,464	72.77	0.44
Widowed	6,367,655	82.42	0.41
Divorced	1,305,106	69.60	0.08
Unknown	33,116	72.80	0.00
TOTAL	15,596,952	76.60	100.00

according to the grouping in the death records into the nine regions of New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain and Pacific; Hawaii and Alaska are excluded.

4.2 Methods

All univariate results are age-standardised. Let $p_j(x)$ be the fraction at age x of deaths in group j and $p(x)$ be the respective proportion in the standard population, which is the total black and white US population between ages 50 and 100. Each age x in group j is re-weighted by $W_i(x) = \frac{p(x)}{p_j(x)}$, such that for each group j the same mean age at death is derived.

Equation 4.1 estimates the simultaneous effects of the characteristics of the decedents on their age at death

$$x_i = \alpha_0 + \beta Y_i + \gamma I_i + u_i \,. \qquad [4.1]$$

Let x_i be the age at death, Y_i the matrix of the indicator variables month of birth, sex, education, race, region and marital status, and I_i the matrix of the two-way interactions between the variables; α_0, β', and γ' are the parameter estimates. The error term u_j follows a normal distribution with mean zero and variance σ^2. The above model assumes that the observed data stem from normal distributions with equal variances but with different means. The descriptive analyses show that the distribution of ages at death deviates significantly from a normal distribution and that the variances of the different categories are not homogenous. The differences in the variances are small, however, and mainly significant because of the large numbers of observations. The sensitivity of the model to the violation of the model assumptions was tested by using different starting ages, and by using log and rank transformations of age. It appears that the results were largely insensitive to these changes.

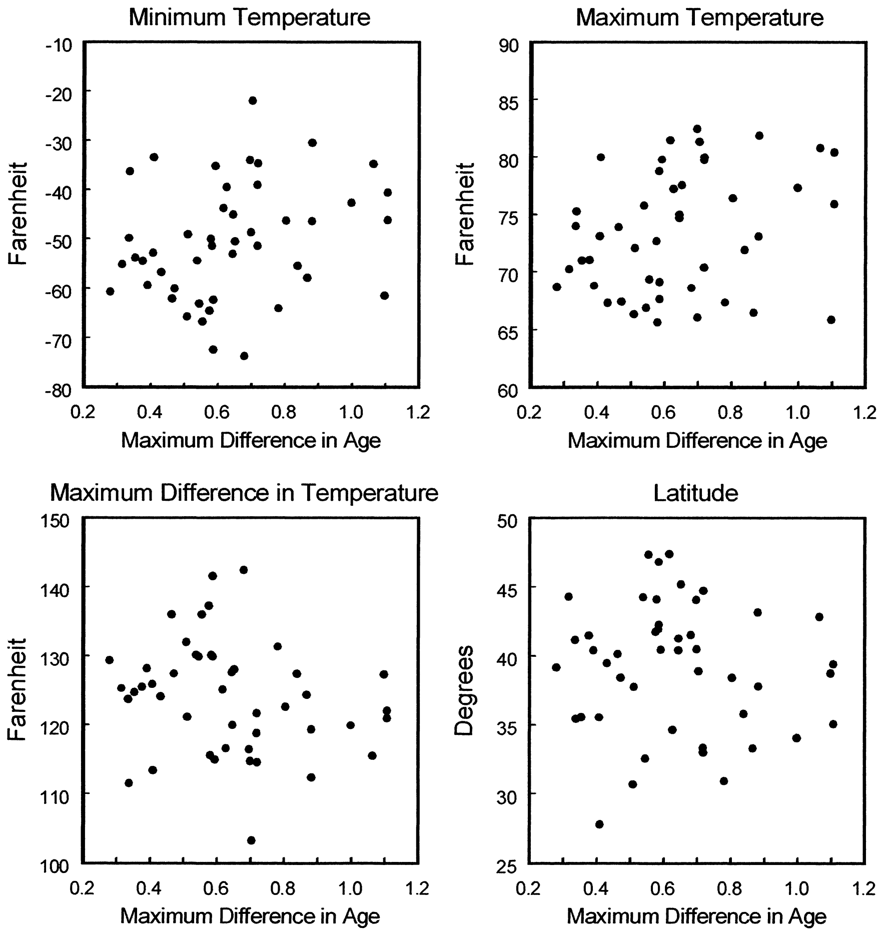

Figure 4.1. Scatterplots of the maximum difference in mean age at death and maximum/minimum temperature, the maximum difference in temperature, and latitude for the 48 contiguous US states.

4.3 Results

A highly significant difference in mean age at death by month of birth exists for US decedents who died between 1989 and 1997. Those born in June and July die about 0.44 years earlier than the October-born. The difference is slightly larger for males (0.434 years) than for females (0.402 years).

Latitude and Temperature

There is no positive correlation between the peak-to-trough differences in the mean ages at death and the latitudes. On the contrary, a small borderline significant negative correlation (Pearson correlation ρ=-.27, p=.06) exists. The correlation of the month-of-birth effect with the maximum difference in temperature, another indicator for latitude, is also negative but not significant (ρ=-.20, p=.18). There is a small positive correlation between the peak-to-trough difference in mean age at death and both maximum (ρ=.26, p=.08) and minimum temperature (ρ=.26, p=.08). When the causes of death are divided into cancer mortality, mortality from cardiovascular disease, and mortality from other natural and non-natural diseases, one finds that the already low correlation results mostly from mortality related to cardiovascular disease. Figure 4.1 shows the scatterplots of the peak-to-trough differences in mean age at death by month of birth and the four variables.

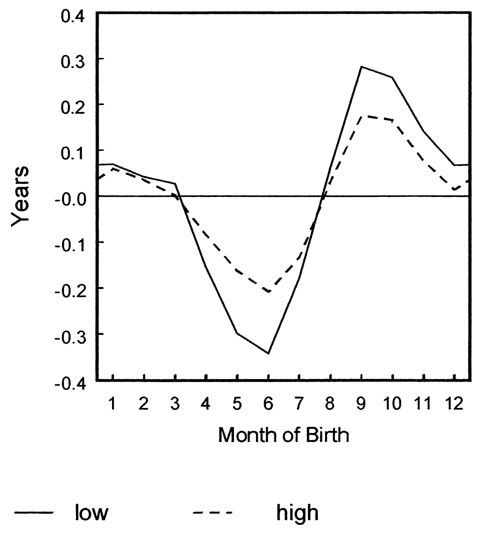

Figure 4.2. Education and the differences in mean age at death by month of birth, US death records 1989 to 1997.

Education

Comparing the two educational groups one finds that the mean age at death of those with a basic education is 78.35 years, while it is 75.43 years for people with a high level of education. This is contrary to the evidence from a large body of literature stemming from research over the last three decades which proves that the lower educated have shorter life spans than the higher educated (Kitagawa & Hauser 1973, Valkonen 1989, Elo & Preston 1996). In the cross-sectional death data, the higher mean age at death of the lower educated is caused by a change in the educational distribution over time. The oldest decedents are more likely to have received basic education than those who died in their 60s or 70s. Sex differences in education are another possible explanation: women have low education but high life expectancy.

Figure 4.2 shows that the age-standardised differences in life span by month of birth vary significantly ($p<.0001$) according to education levels. The difference between the spring trough and the winter peak is 0.62 years (p-value $< .0001$) for those with a low education and 0.38 years for the highly educated (p-value $<.0001$).

Race

The month-of-birth pattern of the 1.7 million blacks with a mean age at death of 73.2 years differs significantly ($p<.0001$) from that of the 13.9 million whites, who died at an average age of 77.03 years (Fig. 4.3). The pattern for whites reveals the familiar features: a sinusoidal curve with a June trough and a September peak. The age-standardized difference between the two months is 0.49 years and is highly significant ($p<.0001$). The pattern for the black decedents, however, differs not only with respect to the number of years between the trough and the peak (0.57 years, $p<.001$) but also with respect to the shape of the curve. The mean age at death is highest for those born between January and March. As in the case of whites, the mean age at death is lowest for decedents born in July.

Figure 4.3. Race and the differences in mean age at death by month of birth, US death records 1989 to 1997.

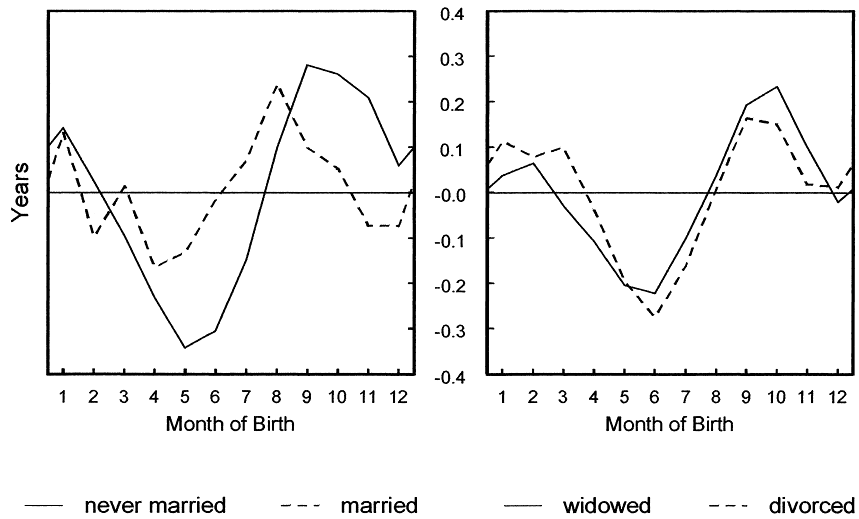

Figure 4.4. Deviation of mean age at death of decedents born in a specific month from average mean age at death by marital status: US death records 1989 to 1997, ages 50–100.

Marital Status

There exists a highly significant difference ($p<.0001$) in the month-of-birth pattern by marital status. As expected, the age-standardized difference between the peak and the trough is largest for the never-married (0.62 of a year, $p<.0001$), and smallest for the married (0.40 of a year, $p<.0001$); the widowed (0.45, $p<.0001$) and the divorced (0.44, $p<.0001$) are intermediate (Fig. 4.4).

Region of Birth

The age-standardised peak-to-trough difference in the month-of-birth pattern increases from the North to the South. The difference is smallest in New England, with 0.31 years and largest in the East South Central Region, with 0.86 years (Table 4.2). The differences in the West are intermediate. The pattern is similar in all regions with a trough in June/July and a peak in September/October. Most regions reveal a secondary peak in the first three months of the year.

Tabelle 4.2. Peak-to-trough difference in mean age at death of decedents born in a specific month by race, education and birth region.

	Age-standardised difference in years					
	US total		Race		Education	
	Peak/ trough	Max difference	Black	White	Low	High
Region of birth						
New England	Sep/Jun	0.31	1.47	0.31	0.45	0.35
Middle Atlantic	Sep/Jun	0.36	0.53	0.37	0.47	0.36
East North Central	Sep/Jun	0.46	0.81	0.45	0.65**	0.34**
West North Central	Oct/Jul	0.44	0.84	0.44	0.67**	0.37**
South Atlantic	Oct/Jun	0.46	0.65++	0.63++	0.53*	0.57*
East South Central	Oct/Jun	0.86	0.68++	1.02++	0.89*	0.81*
West South Central	Oct/Jun	0.69	0.97++	0.77++	0.89**	0.58**
Mountain	Oct/May	0.46	2.60	0.55	0.61	0.53
Pacific	Sep/Jun	0.42	1.68	0.42	0.69	0.33

All peak-to-trough differences are significant at $p<.0001$
++ indicates significant racial differentials at $p<.0001$
** indicates significant educational differentials at $p<.0001$
* indicates significant educational differentials at $p=.05$

Multivariate Results

The differences in the month-of-birth pattern depend on education, race, marital status, and region of birth. In the multivariate analysis of ages at death, the main effects of sex, month of birth, education, race, region of birth, marital status and all the two-way interactions of the variables are highly significant at $p<.0001$. Overall, the model explains 25 per cent of the variation in ages at death. About 86 percent of the model explanation is due to the effect of marital status and 0.4 percent to the effect of month of birth. The large majority (70%) of this 0.4 percent result from the interactions of month of birth with region of birth and race (Table 4.3). This implies that the regional differences in the month-of-birth pattern are neither due to differences in education (Fig. 4.5) nor to differences in race (Fig. 4.6) but they exist independently of them.

The highly significant racial differences ($p<.0001$) in the month-of-birth pattern stem solely from the South. In the North the pattern does not differ by race. In the South the pattern for whites follows a sinusoidal curve with a peak in October and a trough in June/July. The curve for blacks has its major peak in the first three months of the year and its trough in June/July. Contrary to the case of whites, blacks born in the autumn do not experience a major mortality advantage later in life.

Table 4.3. Contribution of the interactions between month of birth and sex, education, race, marital status, and region of birth to the overall model explanation of the month-of-birth effect of 0.4 per cent.

Month of Birth (MoB) effect	Per cent	p-value
MoB	3.3	<.0001
MoB*sex	1.0	<.0001
MoB*education	8.6	<.0001
MoB*race	33.2	<.0001
MoB*marital status	17.4	<.0001
MoB*region of birth	36.5	<.0001
Total contribution of the month of birth effect (0.4%) to the overall model explanation of 25%	100.0	<.0001

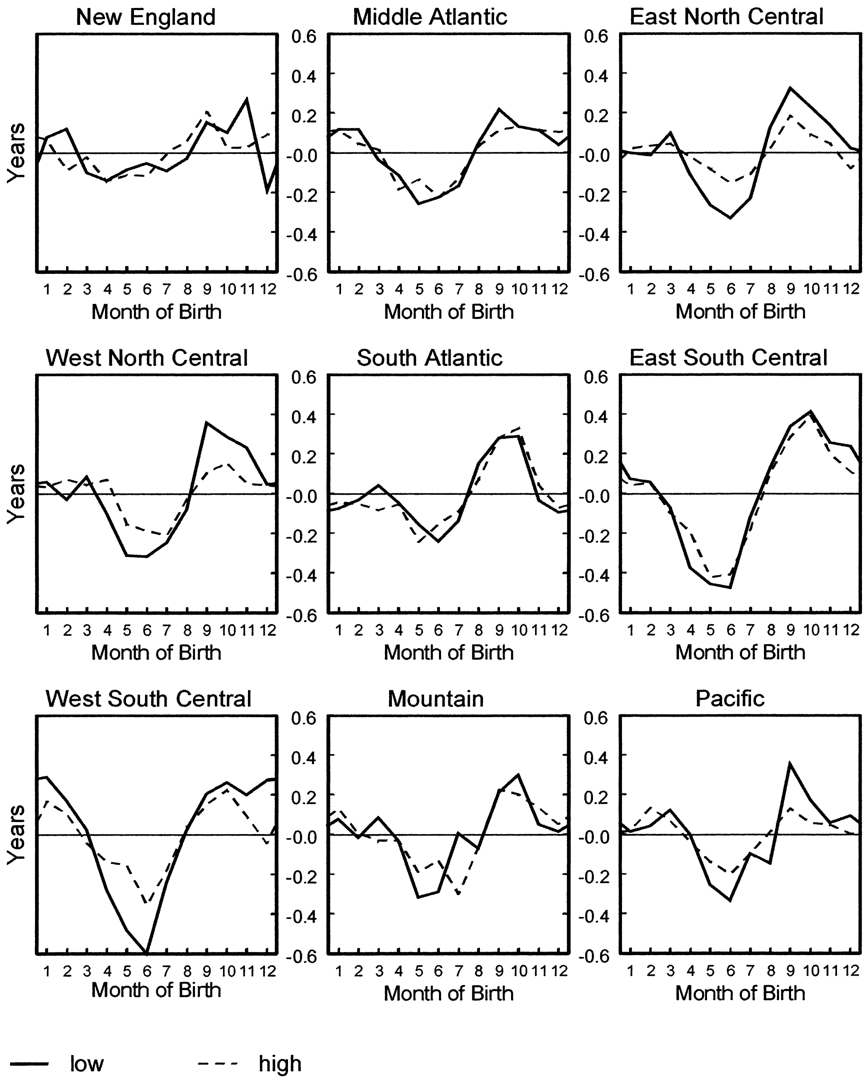

Figure 4.5. Deviation in mean age at death of decedents born in a specific month from average mean age at death by region of birth and education, US death records 1989 to 1997, ages 50-100.

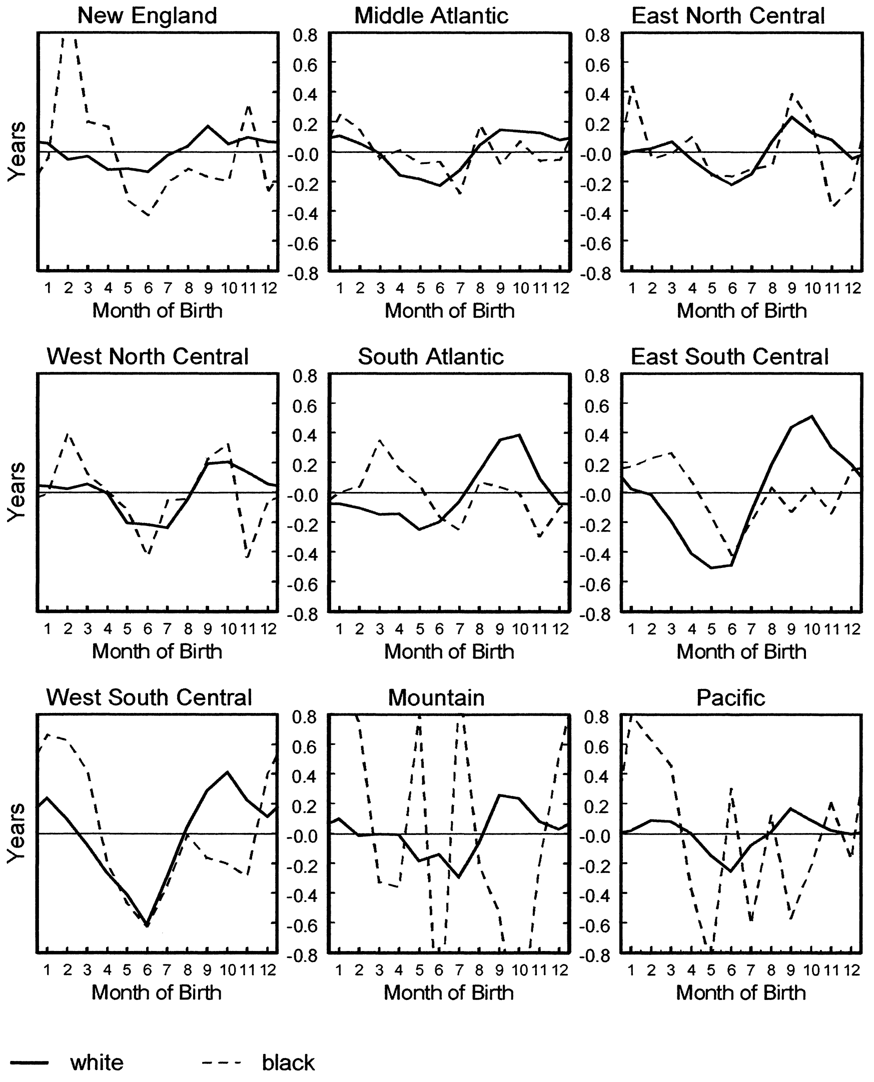

Figure 4.6. Deviation in mean age at death of decedents born in a specific month from average mean age at death by region of birth and race, US death records 1989 to 1997, ages 50-100.

Contrary to the case of whites, blacks born in the autumn do not experience a major mortality advantage later in life. Small numbers cause the erratic month-of-birth patterns for blacks born in the Mountain and Pacific region, since hardly any blacks were born in these two regions in the early part of the 20^{th} century.

The two educational groups follow the same sinusoidal pattern in all regions and the difference between the trough and the peak is generally larger among the poorly educated than among the highly educated. Particularly striking and highly significant is the difference between the educational groups in the East and West North Central regions and in the East and West South Central regions. For both educational groups the regional differences in the month-of-birth pattern increase significantly from the North to the South.

4.4 Conclusion

A significant maximum difference of 0.44 years in mean age at death by month of birth is found for the United States on the basis of 15 million death certificates. This difference is comparable to the differences found for Austria (0.6 years), Denmark (0.3 years) and Australia (0.6 years), but it is much smaller than the 2.6 years that was recently published for Kiev (Vaiserman 2002). The pattern of the differences resembles those of Austria and Denmark.

The differences depend on race, region of birth, marital status, and education. They are larger for the less educated, for the never-married, and for blacks, and they increase from the North to the South. This increase is not caused by differences in the educational or racial composition of the decedents – it is independent of these characteristics. The peak-to-trough difference in life span is slightly larger for African-Americans than for whites and the pattern follows a different curve. This difference in the pattern, however, is only visible in the South.

The month-of-birth effect is largest among the never-married, which supports the view that the month of birth is related to the frailty of the population. There has been ample research to show that there is health selection into marriage (Lillard & Panis 1996) and that the never-married experience higher mortality (Goldman & Hu 1993).

There is a negative correlation between the maximum differences in the month-of-birth pattern and the latitude of state of birth. This allows us to rule out the hypothesis that the differences are related to the seasonality in the duration of sunshine through its effect on neuroendocrine functions. To accept this hypothesis, a positive correlation would have been necessary. The hours of duration of sunshine are more equally distributed over the year at lower latitudes than at higher latitudes. One would therefore expect that the peak-to-trough differences in mean age at death are smaller at lower latitudes than at higher.

The trough in life expectancy for those born in June and July rather than in April and May allows us to reject the hypothesis that high temperature at the time of conception is the responsible factor. Those born in June and July were conceived in September and October, which lies between one and three months after the period of maximum temperatures (July and August).

The rejection of these two hypotheses is consistent with the outcome of a review of more than 250 studies about schizophrenia and bipolar disorder (Torrey et al. 1997, Davies et al. 2003). The studies that tested the existence of a correlation between latitude and the month-of-birth effect came to mixed conclusions: some suggested the existence of a latitude gradient (Dalen 1975, Torrey 1977) while others did not (Torrey et al. 1991). McNeil et al. (1975) were unable to find a correlation between summer temperatures at the time of conception and winter births of individuals with schizophrenia. Hare and Moran (1981) and Watson et al. (1984) did not find a correlation between summer temperatures and winter births. This finding does not exclude the possibility that temperature or duration of sunshine in the first period of life has an effect on one's susceptibility to very specific diseases later in life. However, these diseases are of minor importance with respect to life expectancy. In order to affect life expectancy, major groups of causes of death such as malignant neoplasms and heart disease would need to be correlated with latitude or duration of sunshine, which is clearly not the case in the US.

The regional differences in the month-of-birth pattern are consistent with the hypothesis that nutrition and infectious disease *in-utero* or in the first year of life are the causal mechanisms. The amplitude of the month-of-birth pattern is largest in the South, which is the US region where in the first half of the 20^{th} century diet, particularly in rural areas, was deficient throughout the year and where malnutrition was common in winter and early spring. It is also the part of the US with the highest incidence of infectious diseases, particularly of the gastro-intestinal tract, due to the hot and humid climate.

The multivariate model of age at death shows that educational differentials in the month-of-birth pattern are small compared to racial or regional differences. This finding is further support for the hypothesis that the factors that are mainly responsible for infant mortality in general are also the factors that cause the differences in life span by month of birth. The second chapter of this monograph shows the high level of positive correlation between the month-of-birth pattern in infant mortality and in life expectancy. From Preston and Haines we know that the three single most important factors explaining most of the variance in US child mortality at the beginning of he 20th century were race, size of the birthplace, and region (Preston & Haines 1991). The contemporary view at the beginning of the 20th century was that the mother's health status and whether she breastfed her baby were two factors – in addition to housing, sanitation, and general poverty – that were closely linked to the survival of infants. In other words, infant mortality was largely determined by the nutrition and health of the mother and by breastfeeding, which helped prevent infectious disease in the first months of life.

In the present analysis, the size of the birthplace is missing, which may explain the puzzling finding that the month-of-birth pattern among African-Americans is not much larger than among the white population. African-Americans, particularly in the South, lived mainly in rural areas, where life circumstances were healthier than in urban areas. Among the childhood conditions that predicted survival to advanced ages among African-Americans, the factors that were found to be most predictive were having a farm background, literate parents, and living in a two-parent household (Preston, Hill & Drevenstedt 1998). In other words, correcting for the size of the place of birth may significantly increase the month-of birth effect for African-Americans.

The difference between an urban and a rural environment may also account for the finding that the pattern differs between blacks and whites in the US South. One explanation is that the hard farm-work in the second part of the year prevents African-American infants born in the autumn from experiencing mortality advantages similar to those of the white population. Peak growth *in-utero* is during the third trimester. For infants born in the autumn, this peak growth coincides with a period of heavy work and therefore of high energy expenditures for their pregnant mothers. Evidence from Gambia shows that the high level of energy expenditure and low level of energy intake on the part of pregnant mothers during the last trimester result in a peak-to-trough difference in birthweight of approximately 200-300g (Moore 1998) and in a significant difference in survival to age 45 by month of birth (Moore et al. 1997). A heavy workload on the fields would also prevent mothers from breastfeeding their infants and would expose the infants to a higher risk of infectious disease. In Chapter 7 we further explore the explanation that the poverty of African-Americans in the South at the beginning of the 20th century together with their specific seasonal agricultural workload prevented the autumn-born from experiencing a mortality advantage similar to that of the white population.

Recent research about human skin coloration and vitamin D production points to another possible explanation why the month-of-birth patterns of whites and blacks differ. A recent study (Jablonski & Chaplin 2000) shows that the skin color graduation of indigenous peoples is highly correlated with UV radiation levels. The skin coloration is the compromise between the conflicting requirements of protection of the skin from UV-induced injuries and vitamin D synthesis, which depends on sunlight. Indigenous tropical peoples have more highly melanized skins, which provide better protection against the deleterious effects of UV radiation, such as sunburn and skin cancer. The more lightly pigmented skins of peoples inhabiting higher latitudes are thought as adaptation to lower UV radiation and the importance of maintaining UV induced biosynthesis of vitamin D_3 in the skin. Increasing the melanin in the human skin increases the length of exposure to sunlight that is needed for the production of the previtamin D_3. If the duration of UV exposure of deeply melanized skin is not sufficient then individuals are at much higher risk of vitamin D_3 deficiency and its manifestations in the form of certain diseases. Research findings from migrants from Ethiopia to Israel (Fogelman et al. 1995) showed a high prevalence of vitamin D deficiency among female migrants and highlighted the importance of limited exposure to UV radiation in the development of rickets among migrants from the Indian subcontinent to urban centers in the UK (Henderson et al. 1987).

Vitamin D deficiency in the earliest periods of life has long-term effects. A study based on sera taken during the third trimester of pregnant women found lower levels of vitamin D among black women and an increased risk of schizophrenia among the children of these women (McGrath et al. 2003). An ecological analysis of long-term trends in schizophrenia in the Netherlands and in Australia showed that individuals born during periods of decreased perinatal sunshine are at a higher risk of developing schizophrenia (McGrath et al. 2002). Vitamin D deficiency has been suggested to be related with a variety of diseases, such as schizophrenia, multiple sclerosis, Parkinson's disease, Alzheimer's disease, diabetes I, high blood pressure, heart disease and breast cancer, bowel cancer and ovary cancer.

According to above research African-Americans born in the US are at a higher risk of vitamin D deficiency. The risk may be increased for the fall-born either due to vitamin D deficiency of the mother during pregnancy and lactation or due to a lack of exposure to sunshine of the infant during its first months of life.