5 Month of Birth and Causes of Death in the United States

Since US death records contain more then 15 million decedents, it is possible to verify the month-of-birth pattern for the same causes of death that were analysed in the second chapter on the basis of the Austrian data. In general, the month-of-birth patterns for Austria are confirmed. However, those causes of death that were of borderline significance or insignificant in the Austrian study are now significant in the US data set (e.g. lung cancer, diabetes mellitus).

The following part of this chapter presents the results for different causes of death and relates the findings to existing research. Some literature exists about the relationship between month of birth and the incidence of malignant neoplasms. Extensive research has been done on nervous and mental disorders. Hardly any studies exist, however, about the relationship between month of birth and circulatory disease.

Although the dataset consists of more than 15 million decedents, the month-of-birth patterns for some of the causes of death tend to be erratic, particularly for African-Americans. To strategies are followed in the analysis of the data. Regression models similar to Equ. 3.1 are estimated for each cause of death in order to test whether the month-of-birth patterns differ significantly by sex, race, education and region. The results are reported in Table 5.1 at the end of this chapter.

Cosinor analysis is applied to test whether the month-of-birth pattern follows a sinusoidal fluctuation. In particular, for each cause of death three models are estimated on the basis of the individual death records: the first model tests whether an unimodal sinusoidal function fits the data and defines the period 2π in terms of 12 months (i.e. p=12); the second model tests for a bimodal sinusoidal function and assumes that the period is defined over p=6 months.

$$y = \alpha_0 + \alpha_1 \cos(t) + \alpha_2 \sin(t) + u$$
$$t = month\ of\ birth / p * 2\pi \qquad [5.1]$$

The third model tests whether the sum of a unimodal and a bimodal sinusoidal function fits the data best. Equ. 5.1a allows for modeling of seasonal fluctuations that depart from pure sinusoidal functions. The final model is selected on the basis of the Akaike information criteria max (2LL-2p), where LL denotes the log likelihood and p the number of parameters in the model. Parameter estimates are reported in Table 5.2 at the end of this chapter. The mean ages at death by month of birth together with the estimated sinusoidal functions and the 95% confidence bands are displayed in figures 5.1 to 5.8.

$$y = \alpha_0 + \alpha_1 \cos(t) + \alpha_2 \sin(t) + \alpha_3 \cos(t_1) + \alpha_4 \sin(t_1) + u$$
$$t = month\ of\ birth / p * 2\pi \qquad [5.1a]$$
$$t_1 = month\ of\ birth / \frac{p}{2} * 2\pi$$

5.1 Malignant Neoplasms

There exist highly significant differences (p<=.001) in mean age at death by month of birth for breast cancer, prostate cancer, lung cancer, colorectal cancer and the residual group of other cancers. Differences are significant at p=.05 for stomach cancer, pancreatic cancer and liver cancer, and not significant (p>.05) for uterus cancer. None of the cancers reveal differences by sex or educational status (Table 5.1, Figs. 5.1 and 5.2).

Lung cancer is the only malignant neoplasm with significant differences by race. Similarly to total mortality, mean age at death for blacks peaks among the March-born and does not reveal an autumn peak as is the case for whites. In contrast to total mortality, there is no North-South trend in the magnitude of the difference. Differences are smallest in the Middle Atlantic region and seem to be largest in the Mountain region. It is not only the magnitude that changes between the regions but also the shape of the curve, with the East South Central region revealing a particularly distinct pattern. In addition to breast and lung cancer, the month-of-birth pattern of stomach, colorectal, and the residual group of other cancers also differ significantly by region of birth.

These results are consistent with those of Jansson and Malahy (1981), which are based on the Third National Cancer Survey of the United States, consisting of about 180,000 patients. They find that patients born between January and April are diagnosed with cancer 1–1.5 years later and live one

year longer than patients born from June to August. They do not find differences in the season-of-birth distributions of cancer patients between males and females. They find differences in the month-of-birth distribution for different sites of the lesions: colon, rectum and breast cancer patients have an almost identical distribution, while stomach and lung cancer patients have significantly different season-of-birth distributions. The authors attribute this to differences in the geographic distributions and to social differences.

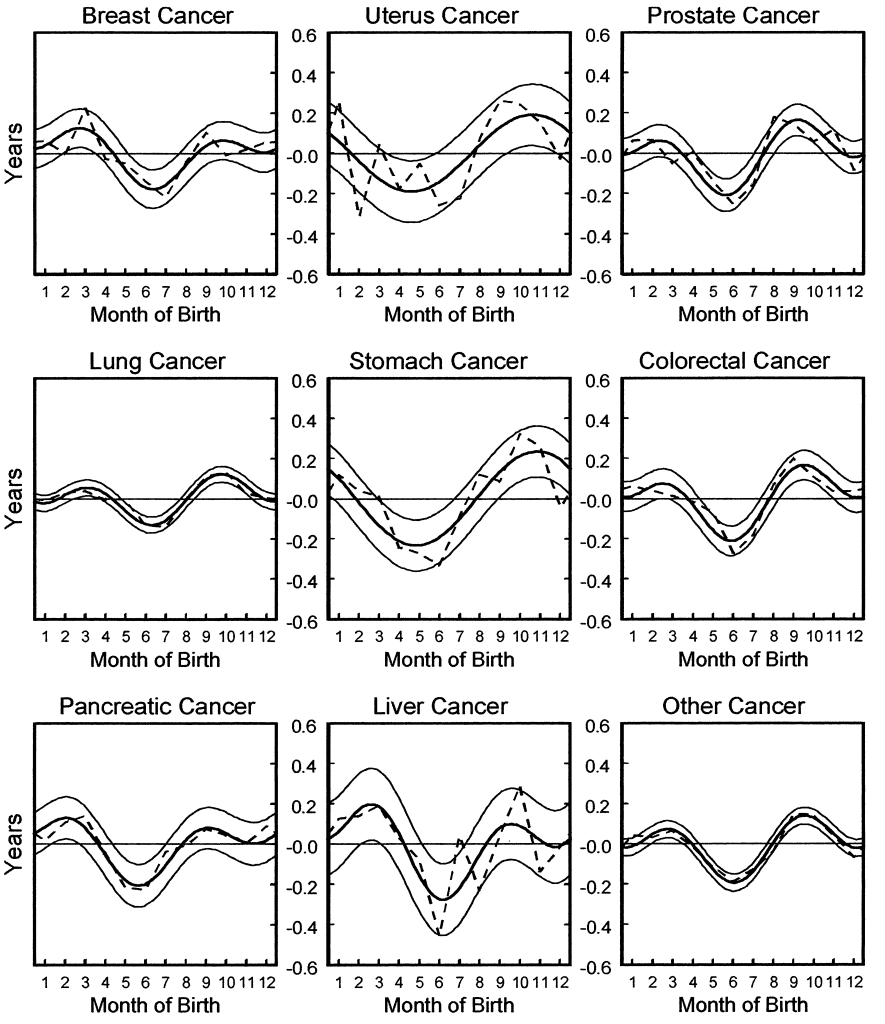

Figure 5.1. Malignant neoplasms: deviation in mean age at death of decedents born in a specific month from the average mean age at death, United States whites, death records 1989 to 1997.

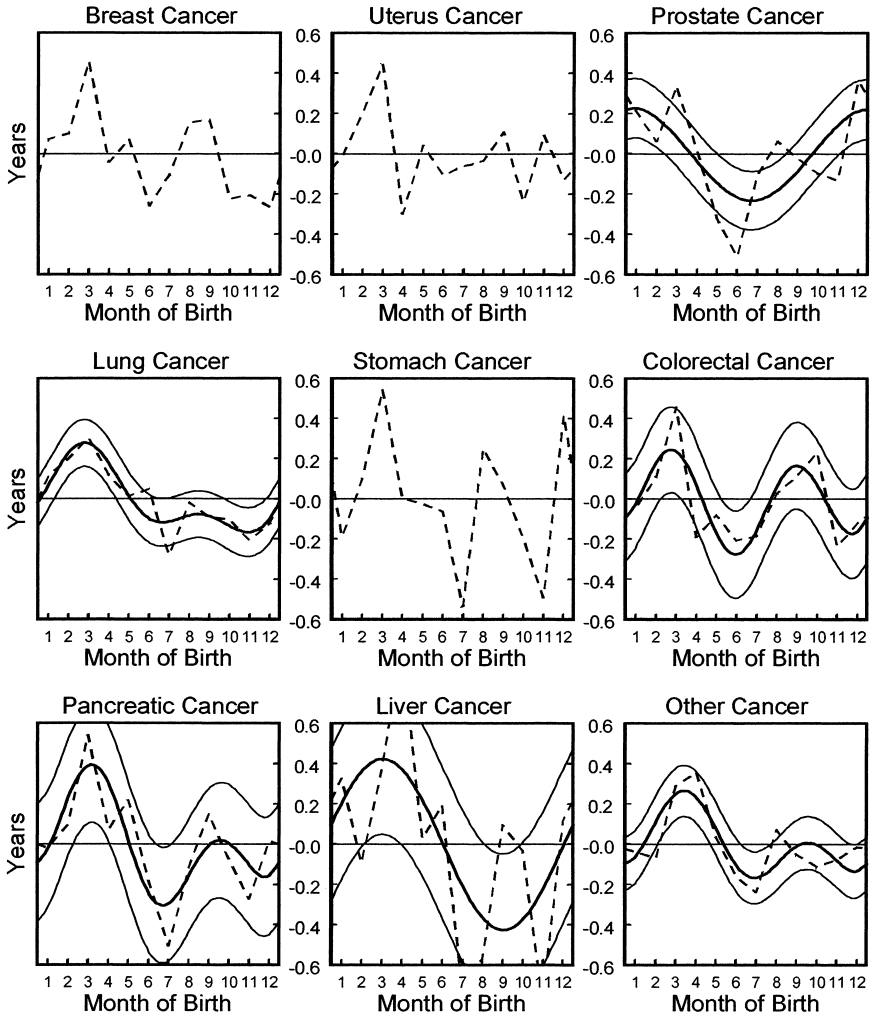

Figure 5.2. Malignant neoplasms: deviation in mean age at death of decedents born in a specific month from the average mean age at death, United States blacks, death records 1989 to 1997.

When the authors compared the maximum difference between the monthly temperature at a given place and the maximum difference between monthly frequencies of birth among cancer patients they find a positive correlation of r=0.89. This is different from the present finding

that only a small correlation exists between the maximum mean age at death by month of birth and temperature variables. Jansons and Malahy's approach, however, confines monthly differences in the seasonal distribution of the number of births with the month-of-birth effect on life span. Thus, the high correlation is most likely the result of the correlation between the seasonal distribution of births and temperature, which has been demonstrated by Lam and Miron (1996), among others. The authors conclude that the relationship between month of birth and cancer probably reflects general differences in the health status of persons born at different times of the year rather than being related to the aetiology of cancer.

A Swedish study compares the birth distribution of 115,670 women with breast cancer to the total number of live births by month of birth from 1858 to 1968 (Yuen et al. 1994). The month of birth was a significant risk factor for breast cancer, but not for other types of cancer (440,948 women). For the older birth cohorts (1880–1920) they find an increased risk for women born in May and June. The pattern for women born after 1950, however, was completely different, with a maximum in autumn. Age and cohort are confounded in their analysis, since these women had a maximum age of 39 and thus represent pre-menopausal breast cancer, whose etiology may differ from breast cancer in post-menopausal women. The authors discuss theories of seasonal fluctuations in pregnancy estrogen, other pregnancy hormones, and post-natal exposures such as diet. They also mention seasonal differences in birth weight as a risk for breast cancer.

Differences in the results regarding the incidence of pre- and post-menopausal breast cancer are also reported in an earlier study by Nakao (1988). A Japanese study (Hu et al. 1996) did not find any differences in the breast cancer risk according to the month of birth for 81,162 women who died of breast cancer.

A series of studies about testicular cancer was conducted in the late 80s. Results, however, are not conclusive. Two studies found significant bi-monthly cycles (Prener & Carstensen 1990, Kinlen & Willos 1987), and one found a significant 4-month cycle (Knox & Cummins 1985). Bernstein et al. (1986) observed a significant annual cycle with a distinct peak in August, confined to teratomas.

Three recent studies describe month-of-birth patterns in childhood leukemia (Sorensen et al. 2001, Higgins et al. 2001, Feltbower et al. 2001) with an increased risk for children born in winter and early spring. Infectious disease is discussed as the causal factor.

5.2 Diseases of the Circulatory System

The differences in life span by month of birth result largely from circulatory diseases (Table 5.1). Acute myocardial infarctions, ischemic heart disease, cerebrovascular disease, the residual group of other heart diseases, as well as the causes of death related to circulatory diseases such as accidental falls, diabetes mellitus (ICD9 250), and pneumonia and influenza show a distinct month-of-birth pattern (Figs. 5.3 and 5.4). People born in the spring die earlier than those born in the autumn. There are no differences by sex, but there are highly significant differences by race. Among blacks the peak in mean age at death is shifted to the first three months of the year. In addition to the differences by race, there exist highly significant differences by marital status, with the never-married born in May and June being particularly disadvantaged. In addition, highly significant regional differences do exist and the month-of-birth effect is strongest in the East South Central and the West South Central regions.

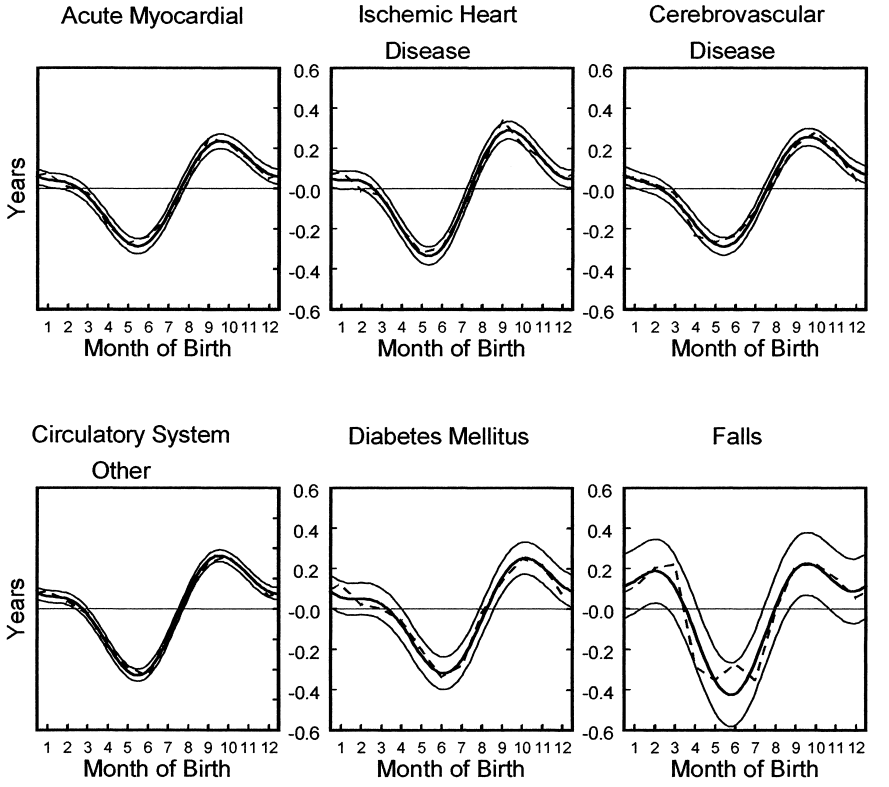

Figure 5.3. Heart disease: deviations in mean age at death for decedents born in a specific month from the average mean age at death, United States whites, death records 1989 to 1997.

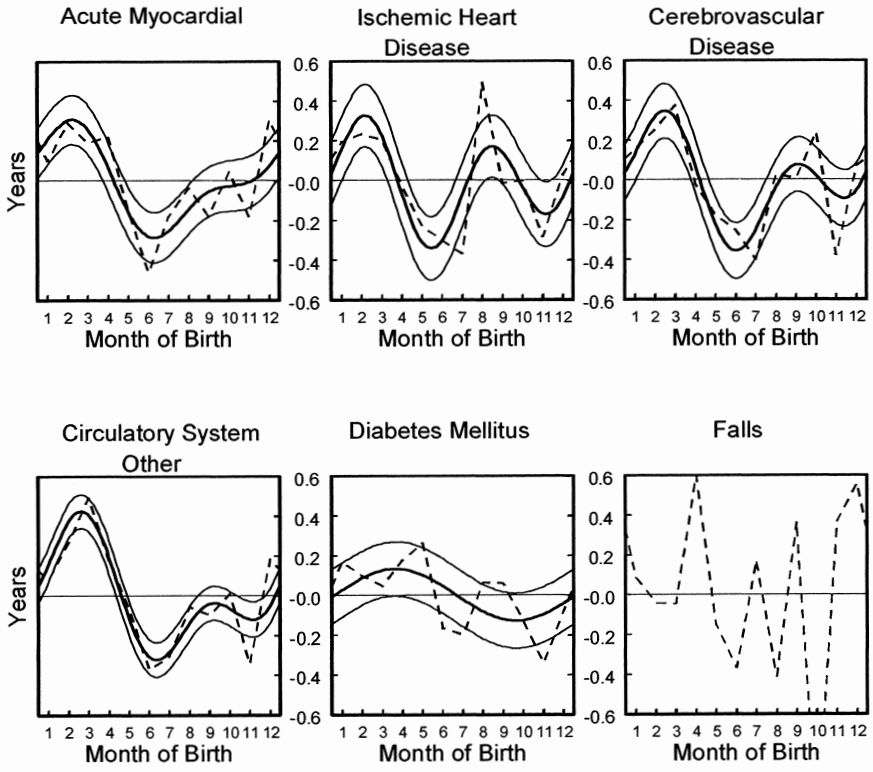

Figure 5.4. Heart disease: deviations in mean age at death for people born in a specific month from the average mean age at death, United States blacks, death records 1989 to 1997.

Most research that explores the effect of early-life circumstances on late-life health and mortality focuses on circulatory diseases (for reviews see Elo & Preston 1992, Kuh & Davey Smith 1993; Barker 1994, Barker 1995, Davey Smith et al. 1997, Davey Smith et al. 2000). Surprisingly, only two studies exist on how these diseases are related to the month of birth. They both explore the relationship between month of birth and death by cerebral haemorrhage. Caroll & Haddon (1964) included deaths under age 34 and did not find any relationship. Nonaka & Imaizumi (2000) studied subarachnaoid haemorrhage (ICD9 code 430) in Japan by comparing the month-of-birth distribution on death records from the years 1986–1994 with the monthly distribution of births for the years 1900–1959. They

found an excess risk of 8 to 23 per cent for people born from June to September. More attention has been paid to diseases that are considered to be a risk factor for circulatory diseases, in particular insulin-dependent diabetes. There are sixteen recent studies (Block et al. 1994, Chen et al. 1998, Dahlquist & Kaellen 1996, Fichera et al. 2001, Helgasson & Jonasson 1981, Hummel et al. 2001, Jongbloet et al. 1998, Kida et al. 2000, Kordonouri et al. 2002, Laron et al. 1999, Neu et al. 2000, Rothwell et al. 1999, Samuelsson et al. 1999, Songini et al. 2001, Ursic-Bratina et al. 2001, Willis et al. 2001) that are concerned with the influence of month of birth on insulin dependent diabetes in children. With the exception of Chen et al., all these studies find a significant relationship between month of birth and the incidence of type I Diabetes. The authors of these studies attribute this relationship primarily to intrauterine infections, mostly during the yearly influenza epidemics in autumn and winter. The exact mechanism is still unknown, however.

5.3 Diseases of the Respiratory System and Infectious Diseases

There exists a highly significant month-of-birth effect for chronic diseases of the respiratory system as well as for pneumonia and influenza (Table 5.1, Fig. 5.5 and Fig. 5.6). The effect differs by region and race and in the case of chronic respiratory diseases also by marital status. Considerable evidence exists that lower respiratory tract infections early in life lead to chronic obstructive lung disease late in life (for a review see Elo & Preston 1992). In young children, viruses are the principal etiological agents that cause lower respiratory tract infections. Elo and Preston point out that, since the lungs of children undergo developmental changes, it is plausible that clinically severe infections could have lasting effects. A large amount of literature exists which shows a significant relationship between the month of birth and atopic disease in childhood. One frequently explored disease is wheezing and asthma.

A study conducted in Queensland, Australia, shows that school children who experience frequent wheezing (one or more episodes per month) are 60% more likely to be born in spring or summer (Duffy 1991). In Hong Kong the prevalence of wheezing is highest for girls born in January/February and lowest for those born in July/August (Lau & Karlberg 1998). In Singapore adolescents born in two main seasons, namely March–May and September–November, show a higher prevalence of asthma and asthma-like diseases (Chew et al. 1998).

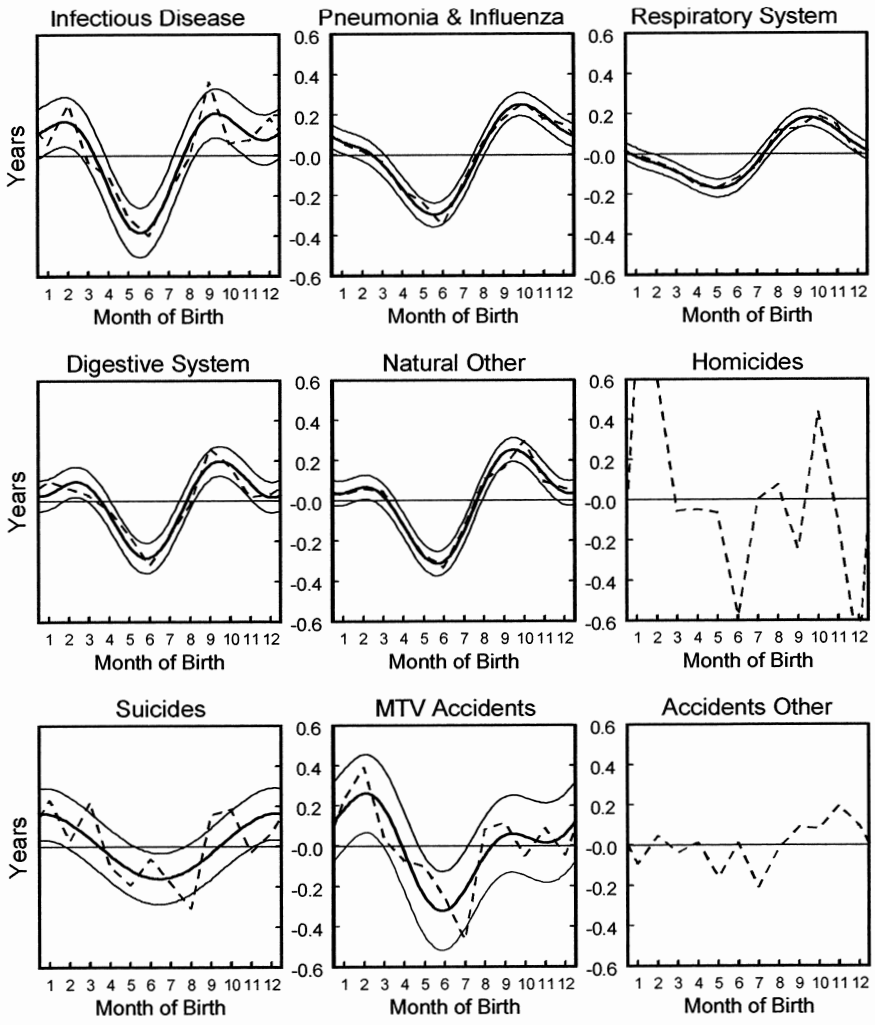

Figure 5.5. Natural and non-natural causes of death: deviation in mean age at death for decedents born in a specific month from the average mean age at death, United States whites, death records 1989 to 1997.

A series of studies explores IgE antibodies. A Swedish study (Nielsson et al. 1997) found that children aged 0–15 born during the tree pollen season (spring) were less likely to develop allergic rhinoconjunctivits, IgE antibodies to pollen, or a positive screening test for IgE antibodies than

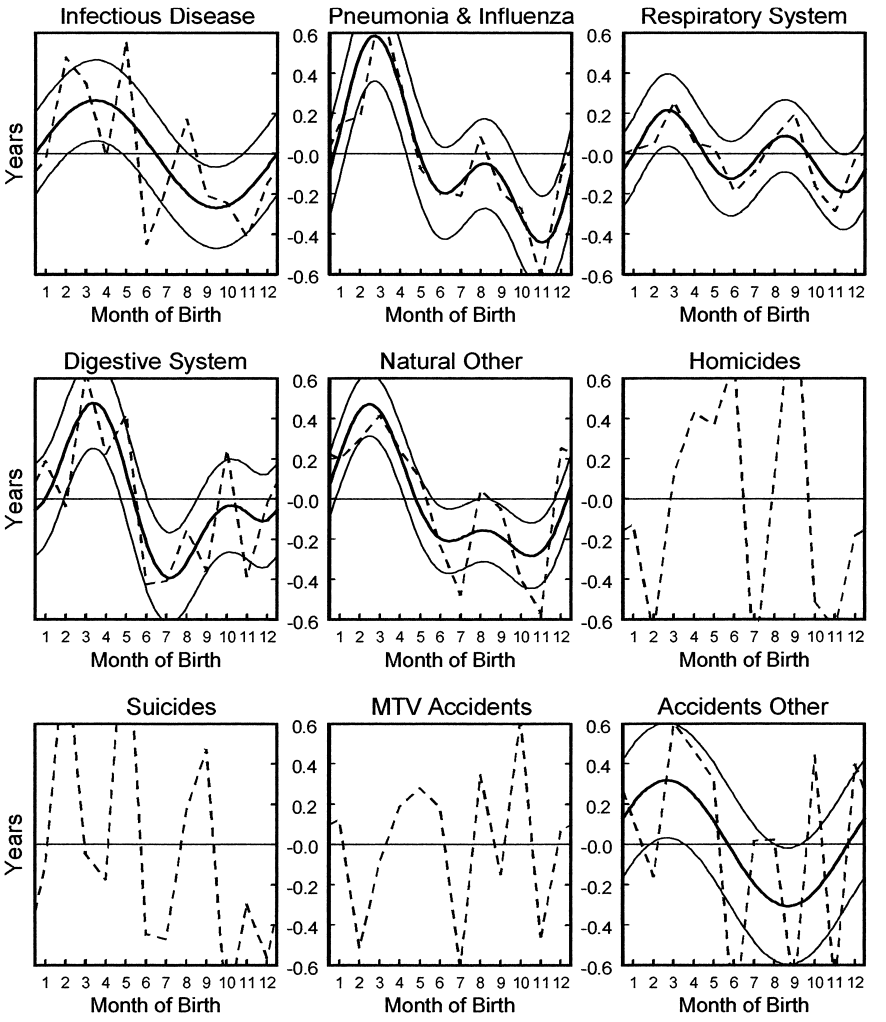

Figure 5.6. Natural and non-natural causes of death: deviation in mean age at death of decedents born in a specific month from the average mean age at death, United States blacks, death records 1989 to 1997.

children born throughout the rest of the year. The prevalence of IgE antibodies to food and animal dander was higher in children born in autumn and winter (September to February). An earlier Swedish study (Eriksson & Holmen 1996) on adults (ages 14+) came to slightly different results, how-

ever. Those born between February and May had a higher prevalence of isolated pollen allergy. A Dutch study (Aalberse et al. 1992) suggests that for the three seasonal allergens birch pollen, grass pollen, and house dust mite an increasingly elevated risk exists for those born up to three months before the main season of the allergen. For cat and dog allergies, those born between November and January had an increased risk as compared to the May-born. The authors conclude that a sensitive period exists in the first months, during which allergy exposure is more likely to prime for an allergy later in life. A French study (de Montis 1998) confirms the results concerning house dust mite allergy and finds a peak for people born in October and a trough for those born in April. Further evidence for there being a significant relationship between allergies to house dust mites and pollen and month of birth comes from a Turkish study (Erel et al. 1998). A German study, however, does not find a correlation between allergic sensitisation and manifest atopic disease and month of birth (Schaefer et al. 1993).

While the studies about the prevalence of wheezing and asthma in childhood by month of birth suggest that the spring-born have a higher risk of atopic manifestation, a study of lower respiratory tract infections in childhood comes to the opposite conclusion. The study is based on British school children and middle-aged adults, and it finds that admission to a hospital for bronchiolitis in the first year of life was three times more common among children born from September to November than among those born from March to May. Admissions for asthma were significantly more common among children and young adults born in the autumn. Among adults however, those born in autumn had a higher forced ventilatory capacity and there was little variation in hospital admissions for chronic bronchitis/emphysema and pneumonia, although there was a tendency for those born in the spring to have higher admission rates (Strachan et al. 1994). The authors conclude that there is no evidence in their study for a causal link between chest illness in infancy and the later development of chronic bronchitis and emphysema.

Significant differences in the month-of-birth effect also exist for mortality from infectious diseases in less developed countries. A recent study of the relationship between month of birth and mortality in Gambia found that those born shortly after the hunger season had a higher risk of dying before their 45th birthday (Moore 1997). All the deaths were caused either by pregnancy-related deaths or by infectious disease. The authors conclude that malnutrition together with a high level of energy expenditure on the part of mothers in their last trimester of pregnancy affected the immune systems of their babies.

Two studies explore the relationship between month of birth and Crohn's disease. They are based on a recent finding that infections early in life or in-utero – measles in particular – seem to be important risk factors for the development of Crohn's disease later in life (Ekbom et al. 1996). However, other studies failed to find a relationship (Nielsen et al. 1998). Since the incidence of measles and other possible infectious agents is seasonal, the seasonal variation might be reflected in the pattern by month of birth in people with Crohn's disease. Results from the two studies exploring the month-of-birth effect are not consistent. In Britain people born in the first half of the year seem to have a slightly increased risk of Crohn's disease (Haslam et al. 2000), whereas in Denmark the peak in prevalence is observed for people born in August (Toft-Sorensen et al. 2001).

A recent study (Ivarsson et al. 2003) explores the month-of-birth pattern of coelic disease in Swedish children below age 15. For children under age two there is an excess of children born during the summer. For children aged two to 15 no pattern exists. The authors suggest that infections may cause the month-of-birth pattern.

5.4 Non-Natural Causes of Death

There exist significant differences in mean age at death by month of birth for suicides, car accidents (MTV), and for the residual group of all other non-natural causes of death (Table 5.2, Fig. 5.5 and Fig. 5.6). Those born in the spring experience a higher risk than those born in the autumn. Considering the large number of deaths that fall into each of these groups, the month-of-birth effect is only of borderline significance.

The evidence concerning a month-of-birth effect for suicide is mixed. A recent study on Alaskan natives showed more suicides among summer births (Kettl et al. 1997). Likewise, Pokorny (1960) found an overrepresentation of suicide cases among people born in July; Salib (2002) of those born in May. Three other studies could not find a relationship (Lester 1987, Lester et al. 1970, Sanborn & Sanborn 1974). Although the relationship between month of birth and the risk of suicide may be surprising at first glance, plausible explanations exist. Suicide at old age is often related to chronic diseases, which according to our results are significantly influenced by the month of birth. Chotai et al. (1999) report differences in suicide methods according to month of birth. Those who preferred hanging rather than poisoning or carbonmonoxide poisoning from a running motor were significantly more likely to be born in February–April than October–January, particularly among males aged 45 or younger. Salib (2002) re-

ports similar findings. The suicide attempts may thus be independent of the month of birth. Those born in late winter/early spring, however, may use suicide methods that lead to death more often than those born in the autumn. This question should lead to research into the effect of month of birth on personality, which, due to the extensive nature thereof, is beyond the scope of this chapter.

Differences in mean age at death by month of birth for car accidents may be explained by the month-of-birth pattern for alcoholism that has been demonstrated repeatedly (Goldberg & Newlin 2000, Modestin et al. 1995, Levine & Wojcik 1999, London 1998, Kunugi et al. 1998, Lang 1931) although two other studies did not find any pattern (Dalen 1975, Watson et al. 1984).

5.5 Diseases of the Nervous System and Psychiatric Disorders

Most of the research on the relationship between month of birth and the incidence of diseases has been conducted for mental disorders, in particular schizophrenia and other bipolar disorders (for reviews see Davies et al. 2003, McGrath & Welham 1999, Torrey et al. 1997, Fossey & Shapiro 1992, Bradbury & Miller 1985). Torrey et al. review more than 250 studies, covering 29 countries from the northern hemisphere and 5 from the southern hemisphere, and find a remarkable consistency in the results. There is a 5 to 8 per cent winter/spring excess of births for both schizophrenia and mania/bipolar disorders. The season-of-birth effect has also been studied for autistic disorder (Barak et al. 1995, Bolton et al. 1992, Ticher et al. 1996), Alzheimer patients (Philpot et al. 1989, Dysken et al. 1991, Henderon et al. 1991, Vitiello et al. 1991, Vezina et al. 1996), and for anorexia nervosa patients (Nielsen 1992, Rezaul et al. 1996, Eagles et al. 2001, Waller et al. 2002, Watkins et al. 2002, Willoughby et al. 2002, Penas-Lledo & Waller 2002). With the exception of a few studies, they all find significant differences in the birth distribution of the patients as compared to the general population or the control group. For diseases of the nervous system significant differences by month of birth have been shown for Parkinson's disease (Miura et al. 1987, Mattock et al. 1988), multiple sclerosis (Miura et al. 1987, Rothwell et al. 1999, Sadovnick et al. 1994, Salemi et al. 2000, Wiberg et al. 1994) and epilepsy (Procopio & Marriott 1998).

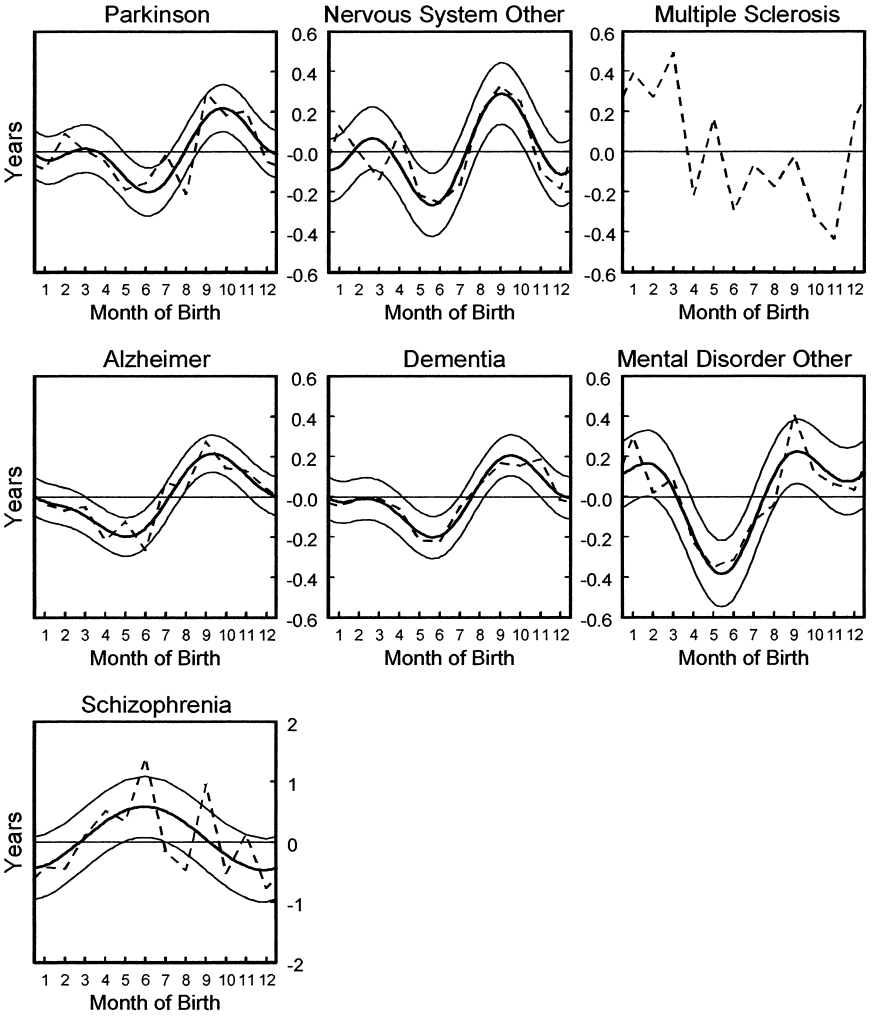

Figure 5.7. Diseases of the nervous and mental system: deviations in mean age at death for decedents born in a specific month from the average mean age at death, United States whites, death records 1989 to 1997.

The present results confirm the findings of all these studies (Table 5.3, Fig. 5.7 and Fig. 5.8) with the exception of multiple sclerosis, which may be attributable to the small number of observations in this study.

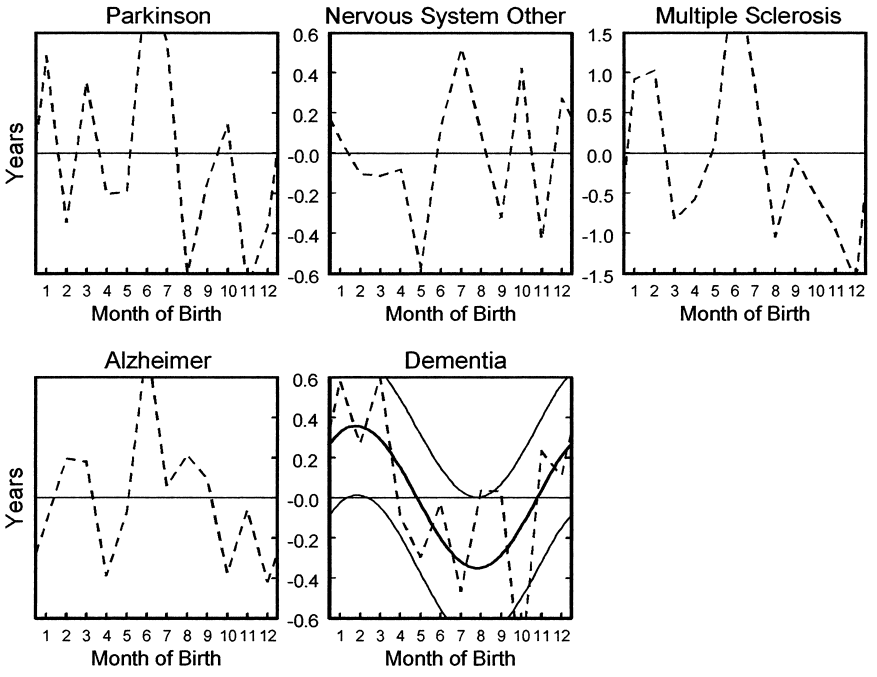

Figure 5.8. Diseases of the nervous and mental system: deviations in mean age at death for decedents born in a specific month from the average mean age at death, United States blacks, death records 1989 to 1997.

5.6 Conclusion

Heart disease, certain types of cancers, and other natural causes of death such as chronic obstructive lung disease reveal a strong month-of-birth pattern. This result is consistent with the extensive literature on the effect of early-life circumstances on late-life disease and mortality. Davey Smith and Kuh (2001) mention stroke, stomach cancer, and bronchitis as important contributors to adult mortality which declined on a cohort basis between the mid-19th century and today. Highly positive correlations between infant mortality in 1921–1925 and mortality from chronic bronchitis, ischemic heart disease, stomach cancer, and rheumatic heart disease have

been demonstrated (Barker & Osmond 1986a), as well as for stroke (Barker & Osmond 1989).

In the US death data, a strong month-of-birth pattern exists also for lung cancer. It is still hotly debated whether lung cancer is partly the result of early-life circumstances (Forsdahl 1973, Barker & Osmond 1986a) or whether it is influenced by indirect effects of the childhood environment mediated through current life-course conditions (Ben Shlomo & Davey Smith 1991, Elo & Preston 1992).The significant month-of-birth pattern suggests that early life factors play a role in the development of lung cancer independently of life-course factors.

There exists a month-of-birth pattern for many different causes of death with very different disease etiologies. This suggests that there is more than one single causal mechanism and that both nutrition and infectious disease are important factors. In the studies by Barker and colleagues mentioned above, heart disease has been primarily linked to fetal development and nutrition during pregnancy. Chronic obstructive lung disease was linked to lower respiratory tract infections during infancy and childhood, which in children are mainly caused by viruses (Elo & Preston 1992). Other diseases in which a major role for persistent viruses has been suggested include multiple sclerosis, Parkinson's disease, juvenile diabetes, and presenile dementia (Elo & Preston 1992). Recent research suggests a relationship between Helicobacter pylori infections in childhood and stomach cancer (Elo & Preston 1992).

A surprising result is the similarity of the month-of-birth pattern of very different causes of death. One generally finds a trough in mean age at death for those born in spring and early summer and a mortality advantage for autumn-born whites and winter-born blacks. One possible explanation is that people born in spring and early summer are doubly disadvantaged. On the one hand, their last trimester *in-utero* falls into the season of the year where the lack of certain micronutrients such as vitamins is most severe. On the other hand, their mortality risk during their first year of life is higher than of those born during other seasons. This is an indication of the effect of infectious diseases, which largely determined infant mortality at the beginning of the 20^{th} century.

For most causes of death, the month-of-birth pattern differs significantly between whites and blacks. In general the trough in mean age at death is similar for both groups, namely in spring/early summer. However, for African Americans the peak is shifted from autumn to winter. This means that the difference in the month-of-birth patterns for the two groups in total mortality is not caused by one or two major groups of causes of death. Rather, it is a general feature of most causes.

The month-of-birth patterns of most cancers, circulatory diseases, pneumonia and influenza, and of diseases of the respiratory system differ significantly by region of birth (not shown). For circulatory diseases the locations of the peaks and troughs remain generally the same for all regions of birth – it is primarily the amplitude that changes. For the other causes of death the peaks and troughs also vary by region of birth. This is further indication that the causal mechanisms that underlie the month-of-birth patterns are different for different diseases.

Table 5.1. Natural causes of death: significance levels of the effect of month of birth (MoB) and its interactions with sex, education, race, marital status, and region.

Causes of death	Total	Model 1	Model 2				
		MoB	Interaction MoB with				
			sex	education	race	marital status	region
Malignant neoplasms							
Breast	299,323	<.0001					.0075
Uterus	71,035	.0782					
Prostate	272,584	<.0001					
Lung	1,175,632	<.0001			<.0001	.0041	<.0001
Stomach	93,877	.0252					.0107
Colorectal	435,972	<.0001					.0078
Pancreatic	201,918	.0443					
Liver	68,710	.0183					
Other	1,328,063	<.0001		.0158	<.0001	.0008	.0005
Circulatory disease and related diseases							
Acute myocardial inf.	1,754,092	<.0001		.0144	<.0001	<.0001	<.0001
Ischemic heart disease	1,249,519	<.0001			<.0001	<.0001	.0177
Cerebrovascular disease	1,150,444	<.0001			<.0001	.0174	.0034
Other circ. system	2,971,581	<.0001			<.0001	<.0001	<.0001
Pneumonia & influenza	591,543	<.0001		.0203	<.0001		.0228
Diabetes mellitus	400,910	<.0001	.0283	<.0001			
Falls	92,389	.0016	.0555	.0307	.0184		

Table 5.1. (continued)

Other natural causes of death							
Infectious disease	242,155	<.0001			.0011		
Respiratory system	998,388	<.0001			.0039	.0027	.0167
Digestive system	523,268	<.0001			<.0001		
Other natural causes	776,124	<.0001			<.0001		.0008
Diseases of the nervous and mental system							
Parkinson	75,016	.0011				.0003	
Multiple sclerosis	12,038	n.s.					
Other nervous system	100,482	.0017					
Schizophrenia	2,459	.0382			.0062	.0101	
Dementia	112,690	.0081				.0345	
Alzheimer	139,188	<.0001		.0118			
Other mental disorders	124,167	<.0001					
Non-natural causes of death							
Homicide	22,124	n.s.					
Suicide	89,929	.0492	.0532				
Accidents motor vehicles	71,538	.0302					
Other accidents	143,821	n.s.					
Non-natural others	5,973	.0328					

Model 1 includes the main effects of month of birth (MoB), education, race, region, marital status, and sex. All main effects are highly significant.
Model 2 includes all main effects and all interaction effects significant at a level of 0.05. The main effect of month of birth is significant for all causes of death.

Table 5.2. Parameter estimates of the cosinor functions defined in Equs. 5.1 and 5.1a for major groups of causes of death; US death certificates 1987-1998, whites.

Causes of death	12 months period		6 months period		F-value	p-value
	sinus	cosinus	sinus	cosinus		
Malignant neoplasms						
Breast	0.043	0.088 **	-0.019	-0.081 **	4.32	0.0017
Uterus	-0.128 **	0.142 **			4.46	0.0116
Prostate	-0.060 **	0.089 ***	0.018	-0.106 ***	8.82	<.0001
Lung	0.020	0.061 ***	-0.039 **	-0.070 ***	16.02	<.0001
Stomach	-0.132 **	0.193 ***			9.68	<.0001
Colorectal	-0.043	0.108 ***	-0.010	-0.104 ***	10.93	<.0001
Pancreatic	0.001	0.109 ***	0.043	-0.086 **	4.53	0.0012
Liver	0.054	0.130 **	-0.008	-0.137 **	2.95	0.0189
Other	-0.026	0.087 ***	-0.022	-0.101 ***	26.01	<.0001
Circulatory disease and related diseases						
Acute myocardial	-0.125 ***	0.170 ***	0.011	-0.092 ***	91.77	<.0001
Ischemic heart disease	-0.163 ***	0.177 ***	0.034 ***	-0.119 ***	89.91	<.0001
Cerebrovascular disease	-0.144 ***	0.177 ***	0.008	-0.087 ***	76.36	<.0001
Other circulatory disease	-0.133 ***	0.198 ***	0.016	-0.108 ***	188.12	<.0001
Pneumonia & influenza	-0.123 ***	0.202 ***	-0.003	-0.082 ***	43.81	<.0001
Diabetes mellitus	-0.064 **	0.217 ***	-0.051 **	-0.095 ***	23.30	<.0001
Falls	-0.042	0.254 ***	0.028	-0.159 ***	8.95	<.0001

Table 5.2. (continued)

Other natural causes of death						
Infectious disease	-0.065	0.222 ***	0.056	-0.137 ***	12.13	<.0001
Respiratory system	-0.128 ***	0.091 ***	0.000	-0.045 ***	34.25	<.0001
Digestive system	-0.053 **	0.150 ***	-0.001	-0.129 ***	17.83	<.0001
Other natural	-0.104 ***	0.172 ***	0.008	-0.131 ***	38.61	<.0001
Diseases of the nervous and mental system						
Parkinson	-0.077 **	0.107 ***	-0.056	-0.092 **	5.02	0.0005
Multiple sclerosis						n.s.
Other nervous system	-0.116 **	0.069	0.018	-0.178 ***	5.03	0.0004
Schizophrenia	0.011	-0.790 **			3.00	0.0500
Dementia	-0.104 ***	0.103 ***	-0.015	-0.088 ***	6.64	<.0001
Alzheimer	-0.151 ***	0.091 **	0.011	-0.062 **	61.62	<.0001
Other mental disorder	-0.091 *	0.214 ***	0.079	-0.131 **	6.91	<.0001
Non-natural causes of death						
Homicides						n.s.
Suicides	0.040	0.159 ***			4.69	<.0001
Accidents motor vehicles	0.069	0.191 ***	0.054	-0.126 **	3.77	<.0001
Other accidents						n.s.
Other non-natural	-0.197	0.472 ***	-0.468 *	0.094	2.00	0.0920

Table 5.3. Parameter estimates of the cosinor functions defined in Equs. 5.1 and 5.1a for major groups of causes of death; US death certificates 1987-1998, blacks.

Causes of death	12 months period		6 months period		F-value	p-value
	sinus	cosinus	sinus	cosinus		
Malignant neoplasms						
Breast						n.s.
Uterus						n.s.
Prostate	0.086	0.214 ***			7.04	<.0001
Lung	0.180 ***	-0.001	0.028	-0.097 ***	7.32	<.0001
Stomach						n.s.
Colorectal	0.036	0.057	0.026	-0.021 ***	2.57	0.0361
Pancreatic	0.198 **	0.040	-0.072	-0.193 **	2.45	0.0438
Liver	0.425 ***	-0.014			3.69	0.0250
Other	0.129 ***	-0.016	-0.066	-0.118 ***	5.14	0.0004
Circulatory disease and related diseases						
Acute myocardial	0.157 ***	0.175 ***	0.033	-0.102 ***	10.30	<.0001
Ischemic heart disease	0.043	0.107 **	0.159 ***	-0.191 ***	7.15	<.0001
Cerebrovascular disease	0.118 ***	0.151 ***	0.051	-0.200 ***	9.96	<.0001
Other circulatory disease	0.224 ***	0.125 ***	0.028	-0.182 ***	32.93	<.0001
Pneumonia & influenza	0.122 **	-0.044			2.61	0.0736
Diabetes mellitus						n.s.
Falls	-0.042	0.254 ***	0.028	-0.159 ***	8.95	<.0001

Table 5.3. (continued)

Other natural causes of death						
Infectious disease	-0.065	0.222 ***	0.056	-0.137 ***	12.13	<.0001
Respiratory system	-0.128 ***	0.091 ***	0.000	-0.045 ***	34.25	<.0001
Digestive system	-0.053 **	0.150 ***	-0.001	-0.129 ***	17.83	<.0001
Other natural	-0.104 ***	0.172 ***	0.008	-0.131 ***	38.61	<.0001
Diseases of the nervous and mental system						
Parkinson	-0.077 **	0.107 ***	-0.056	-0.092 **	5.02	0.0005
Multiple sclerosis						n.s.
Other nervous system	-0.116 **	0.069	0.018	-0.178 ***	5.03	0.0004
Schizophrenia	0.011	-0.790 **			3.00	0.0500
Dementia	-0.104 ***	0.103 ***	-0.015	-0.088 ***	6.64	<.0001
Alzheimer	-0.151 ***	0.091 **	0.011	-0.062 **	61.62	<.0001
Other mental disorder	-0.091 *	0.214 ***	0.079	-0.131 **	6.91	<.0001
Non-natural causes of death						
Homicides						n.s.
Suicides	0.040	0.159 ***			4.69	<.0001
Accidents motor vehicles	0.069	0.191 ***	0.054	-0.126 **	3.77	<.0001
Other accidents						n.s.
Other non-natural	-0.197	0.472 ***	-0.468 *	0.094	2.00	0.0920