Lifespan depends on month of birth

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Month of birth influences adult life expectancy at ages 50+. Why? In two countries of the Northern Hemisphere–Austria and Denmark–people born in autumn (October–December) live longer than those born in spring (April–June). Data for Australia show that, in the Southern Hemisphere, the pattern is shifted by half a year. The lifespan pattern of British immigrants to Australia is similar to that of Austrians and Danes and significantly different from that of Australians. These findings are based on population data with more than a million observations and little or no selectivity. The differences in lifespan are independent of the seasonal distribution of deaths and the social differences in the seasonal distribution of births. In the Northern Hemisphere, the excess mortality in the first year of life of infants born in spring does not support the explanation of selective infant survival. Instead, remaining life expectancy at age 50 appears to depend on factors that arise *in utero* or early in infancy and that increase susceptibility to diseases later in life. This result is consistent with the finding that, at the turn of the last century, infants born in autumn had higher birth weights than those born in other seasons. Furthermore, differences in adult lifespan by month of birth decrease over time and are significantly smaller in more recent cohorts, which benefited from substantial improvements in maternal and infant health.

Remarkable reductions in old-age mortality over the past half century have fueled rapid growth of the elderly population and have led to a substantial increase in life expectancy (1). Yet we still have only limited knowledge about the factors that affect mortality and survival in old age (2). Recent research highlights the role of early-life factors that affect late-life mortality (3). In particular, environmental conditions during the prenatal and early postnatal period have been found to influence adult health and mortality significantly (4, 5) although these results are still controversial (6, 7).

We conjectured that the month of birth may be an indicator for environmental factors that are linked to the seasons of the year. If this conjecture is true, then the patterns of two geographically close populations should resemble each other, and the pattern in the Northern Hemisphere should be mirrored in the Southern Hemisphere. Furthermore, lifespans of people who were born in the Northern Hemisphere but who died in the Southern Hemisphere should resemble the pattern of the Northern Hemisphere.

We obtained data on the populations of Denmark, Austria, and Australia to test our conjecture. For Denmark, the longitudinal data are based on the population register, which follows every person living in Denmark from 1968 to the present. For Austria and Australia, we used information from death certificates for all deaths that occurred in 1988–1996 and 1993–1997, respectively.

We have found that month of birth and remaining life expectancy at age 50 are related. We tested four hypotheses to explain the relationship. The first hypothesis assumes that the interaction between age and the seasons of mortality causes the differences in lifespan by month of birth. For example, people born in April are older than people born in November when the high mortality of winter strikes them. The second hypothesis tests whether the differences are due to unobserved social factors that influence or result from the seasonal timing of births. The third hypothesis explains the differences in adult lifespan by differential survival in the first year of life, whereas the fourth hypothesis assumes that debilitation *in utero* or in the first year of life increases the infant's susceptibility to diseases at adult ages.

Data and Methods

The Danish data consist of a mortality follow-up of all Danes who were at least 50 years old on 1 April 1968; 1,371,003 people were followed up to week 32 of 1998. The study excludes 1,994 people who were lost to the registry during the observation period. Among those who are included in the study, 86% (1,176,383 individuals) died before week 32 of 1998; 14% (192,626 individuals) were still alive at the end of the follow-up.

Exact dates of birth and death are known for a total of 681,677 Austrians who died between 1988 and 1996 and for 219,820 native-born Australians who died between 1993 and 1997 at ages 50+. Similar information was available for 43,074 people born in Britain who died in Australia.

For Denmark, remaining mean life expectancy at age 50 was calculated on the basis of life tables that were corrected for left truncation. The correction was achieved by calculating occurrence and exposure matrices that take into account an individual's age on 1 April 1968. For example, a person who was 70 at the beginning of the study and who died at age 80 enters the exposures for ages 70 to 80 but is not included in the exposures for ages 50 to 69. The central age-specific death rate is based on the occurrence-exposure matrix. The corresponding life-table death rate is derived by the Greville Method (8). For Austria and Australia, we estimated remaining lifespan at age 50 by calculating the average of the exact ages at death. We do not have populations at risk for these two countries and therefore cannot calculate mortality rates for them. We used t tests to perform pairwise comparisons between mean age at death by quarter of birth. By using the Bonferroni method, the α level of each individual test is adjusted downwards by the number of tests to ensure that the overall risk for a number of tests remains 0.05.

To test whether the seasonal difference in the risk of death accounts for the differences in adult lifespan by month of birth, we calculated the monthly deviations from the annual death rates. Given the data we have, we were able to do this only for Denmark. Let x denote age in integer years and let y denote current year. Let i denote age in months since last birthday and let j denote current month; let D_{ij}^{xy} be the number of deaths that occur for people of age $x + i/12$ years at time $y + j/12$, and let T_{ij}^{xy} be the corresponding size of the exposed population at risk of death. Let n_j denote the number of days in current month j. When calculating the exposed population, all deaths were assumed to occur in the middle of each month. The relative deviation of the monthly death rate from the annual death rate, R_{ij}^{xy}, was calculated as

$$R_{ij}^{xy} = \left. \frac{D_{ij}^{xy}}{T_{ij}^{xy} n_j} \right/ M_{xy} \qquad [1]$$

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Abbreviation: ICDN, international classification of diseases number.

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