Month of Birth and Mortality in Sweden: A Nation-Wide Population-Based Cohort Study

Peter Ueda*, Anna-Karin Edstedt Bonamy, Fredrik Granath, Sven Cnattingius
Clinical Epidemiology Unit, Department of Medicine, Solna, Karolinska Institutet, Stockholm, Sweden

Abstract

**Background:** Month of birth – an indicator for a variety of prenatal and early postnatal exposures – has been associated with life expectancy in adulthood. On the northern hemisphere, people born in the autumn live longer than those born during the spring. Only one study has followed a population longitudinally and no study has investigated the relation between month of birth and mortality risk below 50 years.

**Methods and results:** In this nation-wide Swedish study, we included 6,194,745 subjects, using data from population-based health and administrative registries. The relation between month of birth (January – December) and mortality risk was assessed by fitting Cox proportional hazard regression models using attained age as the underlying time scale. Analyses were made for ages >30, >30 to 50, >50 to 80, and >80 years. Month of birth was a significant predictor of mortality in the age-spans >30, >50 to 80, and >80 years. In models adjusted for gender and education for ages >30 and >50 to 80 years, the lowest mortality was seen for people born in November and the highest mortality in those born in the spring/summer, peaking in May for mortality >30 years (25% excess hazard ratio compared to November, [95% confidence interval = 16–34]) and in April for mortality >50 to 80 years (42% excess hazard ratio compared to November, [95% confidence interval = 30–55]). In the ages >80 years the pattern was similar but the differences in mortality between birth months were smaller. For mortality within the age-span >30 to 50 years, results were inconclusive.

**Conclusion:** Month of birth is associated to risk of mortality in ages above 50 years in Sweden. Further studies should aim at clarifying the mechanisms behind this association.

Citation: Ueda P, Edstedt Bonamy A-K, Granath F, Cnattingius S (2013) Month of Birth and Mortality in Sweden: A Nation-Wide Population-Based Cohort Study. PLoS ONE 8(2): e56425. doi:10.1371/journal.pone.0056425

Editor: Samuli Helle, University of Turku, Finland

Received November 2, 2012; Accepted January 10, 2013; Published February 15, 2013

Copyright: © 2013 Ueda et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Funding: The study was funded by the MD-PhD Program at Karolinska Institutet. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing Interests: The authors have declared that no competing interests exist.

* E-mail: peter.ueda@gmail.com

Introduction

A large body of epidemiological evidence suggests that risks of diseases and mortality in adult age is not only determined by genetics and lifestyle but also by factors acting in early life.[1–3].

Month of birth is frequently used as a proxy for a wide array of prenatal and early postnatal environmental exposures related to season. These include nutritional status, ambient temperature, sun exposure, exposure to infections and other environmental influences. [4,5] Observations from the northern hemisphere demonstrate that people born in the autumn (October-December) live longer than those born during spring (April-June).[6–8].

Whether the effect of month of birth on mortality risk change during the life course is of interest to clarify, as risks of diseases and prevailing causes of deaths vary between age-spans. Most studies have only indirectly studied the influence of month of birth on mortality by cross-sectional reviews of death certificates from which average age at death has been calculated. [7,9] To our knowledge, there is only one longitudinal population-based study that has investigated the association between month of birth and mortality. In a closed cohort, more than 1.3 million Danes aged 50 years or more were followed for 30 years. Paralleling the findings of the cross-sectional studies, subjects born in autumn were shown to have a longer remaining life expectancy compared to spring born subjects. [8].

In this nation-wide study, we included over 6 million subjects who lived in Sweden in 1991 and who were more than 30 years sometime during the follow-up time of 20 years. We assessed the relation between month of birth and mortality in the ages >30, >30 to 50, >50 to 80 and >80 years.

Methods

Study Population and Data Sources

Data used in the study was obtained from population-based health and administrative registries in Sweden. Cross-linkage across these registries was possible using the person-unique Personal Identification Number (PIN), assigned to all Swedish residents [10]. Using the Swedish Total Population Register, we identified all Swedish-born subjects who were living in the country on the 1st of January 1991. We included all subjects who were more than 30 years old before the end of follow up (December 31st, 2010; n = 6,583,693). From the Swedish Total Population Register, we also retrieved information about dates of emigration and death. Data on subjects’ educational level - categorized into primary, secondary and higher education (studies at university) -
was obtained from The Education Register for the years 1990, 1995, 2000, 2005 and 2010. The highest educational level reached during the study time was defined as the subject's education. Subjects were followed until death, emigration or end of follow-up (December 31st 2010). The study was approved by the regional ethics committee in Stockholm (Dnr 19803/2011). The committee waived the need for written consent from the participants.

Statistical Methods

The population was divided by month of birth into twelve groups. To adjust for cohort effects, all analyses were stratified on 10-year birth cohorts. The relation between quarter of birth (January-March, April-June, July-September, and October-December), and education status was assessed with Chi-2 test. Quarter of birth year was used in order to decrease the number of comparisons in the test.

We assessed the association between month of birth and mortality by fitting Cox proportional hazards regression models using attained age as the underlying time scale. The analyses only included ages above 30 years. Left truncation was adjusted for by calculating an individual's age on the 1st of January 1991. Subjects contributed with person-time only in the age-spans that they belonged to during the study time. For example, a subject who was 20 years at the start of the study entered the study at the age of 30, i.e. 10 years after start of study follow-up, and contributed with person-time during the 10 years of remaining study time, between the age of 30 and 40.

As previous studies have shown lowest mortality for subjects born in November, [8] this month was used as reference in the Cox regression analyses. Relative risks are presented as the excess hazard ratio (EHR) in per mille (Hazard ratio –1)*1000. Analyses were first conducted for the ages of >30 years and separate analyses were then performed for the age-spans >30 to 50, >50 to 80 and >80 years. The crude models were followed by analyses adjusted for sex and education. Due to the computational burden, it was not possible to statistically test the differences in month of birth effects on mortality between the chosen age-spans. For ages >30 years, sex stratified analyses adjusted for education were also performed.

Six percent (n = 388,948) of the subjects lacked education data. We therefore compared results from crude analyses of month of birth and mortality in the age-spans >30, >30 to 50, >50 to 80 and >80 years, when including and excluding subjects with missing information on education. As the influence of month of birth on mortality risks did not essentially differ between the models, subjects without education data were excluded in the analyses presented in the study (Figure S1 provides information on mortality >30 years in all subjects as compared to subjects with data on education, results from other comparisons are available on request).

In post-hoc analyses, we also investigated potential interaction effects between month of birth and education, as well as month of birth and sex in the age-span >30 years. Interaction variables were created for education/sex categories (three and two categories, respectively) and the four months with the highest and lowest hazard ratios respectively. In complementary analyses, we also tested for differences in mortality between subjects born in December and January. Statistical analyses were conducted in SAS version 9.0 (SAS Institute, Cary, North Carolina, USA).

Results

A total of 6,194,745 subjects contributed with person-time to the study. During the time of follow-up, 1,287,927 (20.8%) of the

| Month of Birth and Mortality | Table 1. Number of subjects and proportion of the population that died during the study time by age-span, sex and education group. |
|-----------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| Sex                        | Proportion dead (%) | Proportion dead (%) | Proportion dead (%) | Proportion dead (%) | Proportion dead (%) | Proportion dead (%) | Proportion dead (%) | Proportion dead (%) |
| Male                       | 3095/006            | 25.0               | 1,992/251           | 19.6               | 1,992/251           | 19.6               | 1,992/251           | 19.6               |
| Female                     | 3095/006            | 20.5               | 1,992/251           | 19.6               | 1,992/251           | 19.6               | 1,992/251           | 19.6               |
| Education                  | Proportion dead (%) | Proportion dead (%) | Proportion dead (%) | Proportion dead (%) | Proportion dead (%) | Proportion dead (%) | Proportion dead (%) | Proportion dead (%) |
| Primary                    | 3095/006            | 25.0               | 1,992/251           | 19.6               | 1,992/251           | 19.6               | 1,992/251           | 19.6               |
| Secondary                  | 3095/006            | 20.5               | 1,992/251           | 19.6               | 1,992/251           | 19.6               | 1,992/251           | 19.6               |
| Higher                     | 3095/006            | 20.5               | 1,992/251           | 19.6               | 1,992/251           | 19.6               | 1,992/251           | 19.6               |
| Subjects (n = 6,194,745)   | Deaths (n = 1,287,927) | Subjects (n = 3,989,786) | Deaths (n = 47,595) | Subjects (n = 4,240,338) | Deaths (n = 584,611) | Subjects (n = 584,611) | Deaths (n = 655,535) | Subjects (n = 655,535) | Deaths (n = 736,458) |
subjects died. The proportion of the population that died during the study time increased with age-span, male sex and lower education. (Table 1).

Quarter of birth year was significantly associated to education status (p<0.001, Chi-Square = 1559.06, degrees of freedom = 6). Higher education was slightly more common among subjects born from January to June (monthly rates ranged from 27 to 28%) than among subjects born from July to December (25–26%). Subjects born from January to June were consequently less likely to have only secondary education (41% in all months) and primary education (31–32%) than subjects born from July to December (secondary education: 42% in all months; primary education: 32–33%).

In the total population above 30 years of age, month of birth predicted mortality in the crude model, and adjusting for sex and education did not attenuate these associations. Compared to November, being born in January to September was associated with significantly increased mortality, and the excess hazard ratio was highest from April through July. When the analyses were stratified by sex (and adjusted for education), the patterns were similar, although there were slight sex differences with respect to month of birth and mortality risk. The lowest mortality risks were seen in October or November in all analyses (Table 2).

We found no interaction effects between sex and month of birth and mortality risk in a model where interaction variables were created with the four months of highest (April–July) and lowest (September–December) mortality risks in the crude analysis (p = 0.518 Chi-square = 1.3171, degrees of freedom = 2). In a similar model, there was a significant interaction between education and month of birth and mortality (p = 0.035 Chi-Square = 10.3668, degrees of freedom = 4). The interaction was derived mainly from a lower month of birth-effect on mortality in the high risk months for the middle education group compared to the low and high education group (data not shown).

Associations between month of birth and age-specific mortality are illustrated in Table 3 and Figure 1. Month of birth was not a significant predictor of mortality in the age-span >50 to 50 years, but predicted mortality both at >50 to 80 and >80 years (Table 3). Peak mortality was seen for birth month April in ages >50 to 80 years and for August in ages >80 years. Overall, the mortality was highest for subjects born during the spring and summer months in both age-spans and lowest for subjects born in October–December. (Table 3 and Figure 1). There were no significant differences in mortality risks between December and January in any of the investigated age-spans (data not shown).

**Discussion**

In this large population-based study, we found that month of birth was a significant predictor of mortality in the age-spans >50, >50 to 80 and >80 years. The highest mortality was seen for people born in the spring/summer, peaking in April (>50 to 80 years, adjusted model), May (>30 years) or August (>80 years), with a corresponding trough in the autumn. In the age-span >30 to 50 years, results were inconclusive.

As for the ages above 50 years, the findings of this study are in broad agreement with previous reports from the northern hemisphere: autumn-born have a survival advantage compared to those born in the spring and summer. Seemingly, these effects were more pronounced in the age-span >50 to 80 years compared to >80 years. One possible explanation for this is selective mortality: irrespective of month of birth, the frailer will die first. With increasing age, the remaining population will constitute an

| Number of deaths (n = 1,287,927) | Crude | Adjusted for sex and education Male | Adjusted for sex and education Female |
|---------------------------------|-------|----------------------------------|--------------------------------------|
| Month                          | EHR % | 95% CI EHR % | 95% CI | EHR % | 95% CI | EHR % | 95% CI |
| January                        | 109,186 | 13 | 4 to 22 | 14 | 5 to 23 | 14 | 2 to 26 | 14 | 1 to 27 |
| February                       | 103,590 | 11 | 2 to 20 | 14 | 5 to 23 | 16 | 4 to 28 | 12 | -1 to 25 |
| Mars                            | 118,627 | 12 | 3 to 20 | 14 | 5 to 23 | 14 | 2 to 26 | 14 | 2 to 27 |
| April                           | 113,407 | 19 | 11 to 28 | 23 | 14 to 32 | 25 | 13 to 38 | 20 | 7 to 33 |
| May                             | 114,741 | 20 | 11 to 28 | 25 | 16 to 34 | 26 | 14 to 38 | 23 | 11 to 36 |
| June                            | 106,019 | 16 | 7 to 25 | 21 | 12 to 30 | 27 | 15 to 40 | 13 | 1 to 26 |
| July                            | 106,594 | 21 | 12 to 30 | 23 | 14 to 32 | 19 | 7 to 32 | 27 | 14 to 40 |
| August                          | 104,524 | 17 | 8 to 26 | 19 | 10 to 28 | 20 | 8 to 32 | 18 | 5 to 31 |
| September                       | 109,333 | 10 | 1 to 19 | 11 | 2 to 20 | 12 | 0 to 24 | 10 | -3 to 23 |
| October                         | 102,188 | 2 | -7 to 11 | 3 | -6 to 12 | 6 | -6 to 19 | -1 | -14 to 12 |
| November                        | 96,229 | 0 (ref) | ref | 0 (ref) | ref | 0 (ref) | Ref | 0 (ref) | ref |
| December                        | 103,489 | 5 | -4 to 14 | 6 | -3 to 14 | 5 | -7 to 18 | 6 | -7 to 19 |
| P                               | <0.001 | <0.001 | <0.001 | <0.001 |
| Degrees of freedom              | 11 | 11 | 11 | 11 |
| Chi –Square (Likelihood Ratio)  | 53.4873 | 75.6558 | 44.7231 | 38.4738 |
| Chi –Square (Score)             | 53.4316 | 75.5744 | 44.6961 | 38.452 |
| Chi –Square (Wald)              | 53.2639 | 75.329 | 44.6145 | 38.3862 |

Table 2. Number of deaths and excess hazard ratio (EHR) in % compared to November (95% confidence interval) in the age-span >30: crude model, adjusted for sex and education, male (adjusted for education) and female (adjusted for education) and with p-value for type 3-test.
increasingly homogenous group of robust individuals, and differences in mortality risk by month of birth will therefore gradually diminish. [9].

Possible explanations for the association between month of birth and mortality after 50 years have been scrutinized by others. [9] Seasonal differences in nutrition availability and infections have been proposed as the main causes of the observed correlations. [9] In the beginning of the 20th century, food supply, especially fruit and vegetables, was much dependent on season. Mothers to children born in the autumn are likely to have had a better nutritional status during pregnancy - especially during the third trimester when the peak growth in fetal weight occurs [11] – as compared to the mothers of spring-born children. Evidence linking nutrition in utero to adult disease is supportive of this hypothesis. [2] Seasonality in birth weight – an indicator of fetal nutrition and a controversial risk factor for adult disease – has been observed in different parts of the world [12] and attributed to both nutrition [13] and the load of infectious diseases on the mother during the third trimester of pregnancy. [14,15] Several ecological studies have observed that cohorts exposed to infections in early life are at increased risk for disease and death in late life. [16,17].

Recently, vitamin D-deficiency has been highlighted as an early life nutritional factor of potential importance to health later in life. [18] It has been suggested that the prenatal period constitutes a critical window during which vitamin D-deficiency may predispose the fetus for adult-onset disease. Although there are small contributions from diet and supplements, skin exposure to ultraviolet light (UVB) is the main determinant for vitamin D-levels in humans. [19] On high latitudes, vitamin D levels are higher in both mothers and neonates during the summer as compared to the winter. [20,21] It can thus be hypothesized that individuals born in the spring in Sweden – a country with large

Figure 1. Excess hazard ratio by month of birth. Models for age-spans >30 to 50, >50 to 80 and >80 years presented as % compared to November and adjusted for education and sex. doi:10.1371/journal.pone.0056425.g001

Socioeconomic status - in this study indicated by educational level - is of importance to consider in month of birth studies. Socioeconomic status is a life course factor affecting disease and mortality risks. Preferences regarding the timing of having children may vary between couples of different socioeconomic groups. Month of birth-patterns in mortality may simply reflect such socioeconomic differences in seasonality of birth [30,31], and socioeconomic factors are therefore potential confounders. In our study, those born in the first half of the year were more likely to have a higher education than subjects born in the second half of the year. However, the association between month of birth and mortality remained after controlling for education. Moreover, educational level of an individual is closely linked to the educational level of the parents. [32,33] As parents in low socioeconomic groups may have been more affected by seasonal fluctuations in nutrition availability in the beginning of the 20th
Table 3. Number of deaths and excess hazard ratio (EHR) in % compared to November (95% confidence interval) in the age-spans >30 to 50, >50 to 80 and >80 years: crude models and adjusted for sex and education with p-value for type 3-test.

| Month       | >30 to 50 | >50 to 80 | >80        |
|-------------|-----------|-----------|------------|
|              | Number of deaths | Crude | Adjusted | EHR % | 95%CI | EHR % | 95%CI | EHR % | 95%CI | Crude | Adjusted | EHR % | 95%CI | EHR % | 95%CI | EHR % | 95%CI |
| January      | 3,842     | -17       | -61 to 29 | -21     | -64 to 25 | 53,849 | 18 | 6 to 31 | 20 | 8 to 33 | 51,477 | 9 | -4 to 22 | 9 | -4 to 22 |
| February     | 3,654     | -33       | -76 to 13 | -28     | -72 to 18 | 51,538 | 21 | 8 to 34 | 25 | 13 to 38 | 48,381 | 4 | -9 to 17 | 5 | -8 to 18 |
| Mars         | 4,472     | -13       | -55 to 32 | -5      | -47 to 40 | 60,173 | 27 | 15 to 39 | 30 | 18 to 42 | 53,963 | -3 | -15 to 10 | -2 | -15 to 11 |
| April        | 4,449     | -14       | -57 to 30 | -4      | -47 to 41 | 58,414 | 38 | 25 to 50 | 42 | 30 to 55 | 50,524 | 2 | -11 to 15 | 4 | -9 to 17 |
| May          | 4,299     | -30       | -72 to 14 | -19     | -62 to 26 | 59,210 | 30 | 18 to 43 | 36 | 24 to 49 | 51,218 | 12 | -1 to 25 | 16 | 3 to 29 |
| June         | 3,910     | -32       | -75 to 13 | -29     | -72 to 16 | 55,138 | 30 | 17 to 42 | 34 | 21 to 46 | 46,957 | 5 | -8 to 18 | 10 | -3 to 24 |
| July         | 3,950     | -17       | -60 to 29 | -18     | -61 to 28 | 55,444 | 33 | 21 to 46 | 35 | 23 to 48 | 47,189 | 10 | -3 to 23 | 12 | -1 to 25 |
| August       | 3,843     | -3        | -47 to 43 | -5      | -49 to 42 | 53,567 | 21 | 8 to 33 | 22 | 10 to 35 | 47,098 | 15 | 1 to 28 | 17 | 4 to 31 |
| September    | 3,867     | -21       | -65 to 25 | -21     | -64 to 25 | 55,449 | 18 | 5 to 30 | 18 | 6 to 30 | 50,004 | 5 | -8 to 17 | 6 | -7 to 19 |
| October      | 3,893     | 21        | -24 to 69 | 20      | -26 to 67 | 51,677 | 9 | -3 to 22 | 10 | -3 to 22 | 46,605 | -7 | -20 to 6 | -6 | -19 to 7 |
| November     | 3,575     | 0 (ref)   | ref       | 0 (ref) | ref       | 48,544 | 0 (ref) | ref | 0 (ref) | ref | 44,095 | 0 (ref) | ref | ref |
| December     | 3,841     | 30        | -16 to 78 | 25      | -20 to 73 | 52,529 | 9 | -4 to 21 | 10 | -2 to 23 | 47,100 | -2 | -15 to 11 | -1 | -14 to 12 |
| P            | 0.115     | 0.287     | <0.001    | <0.001  | <0.001   | 0.029  | 0.03 |
| Degrees of freedom | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| Chi-Square (Likelihood Ratio) | 16.3981 | 12.8955 | 71.0564 | 91.2901 | 21.4824 | 28.0583 |
| Chi-Square (Score) | 16.4906 | 12.9473 | 70.9598 | 91.1583 | 21.4823 | 28.0622 |
| Chi-Square (Wald) | 16.768 | 13.1022 | 70.6689 | 90.7603 | 21.4818 | 28.0738 |

doi:10.1371/journal.pone.0056425.t003
century than parents in high socioeconomic groups, education can also be seen as an indicator for the perinatal environment. The effects of month of birth on adult mortality would in this case interact with education. However, the interaction effect found in our study was in the form of a lower month-of-birth-effect on mortality risk for the group with secondary education compared to the low and high education group. This is not in line with any known hypothesis and could be a chance finding.

Cross-sectional studies have found that an effect of month of birth is present for a diverse range of causes of death, including cardiovascular disease and malignant neoplasms [9], which are the major causes of death after 50 years in Sweden [34]. It is therefore feasible to assume that these month of birth effects are also present in our study population. In the youngest age-span of this study (>30 to 50 years), suicide, accidents and other causes of death related to social factors are more prominent [35]. Apart from the relatively low number of deaths occurring in this age-span compared to older ages, different pathways between month of birth and mortality could explain the inconclusive and different month of birth-pattern seen in ages >30 to 50 years as compared to >50 to 80 and >80 years.

This study, comprising observations from over 6 million subjects, is the largest longitudinal population-based study assessing the relation between month of birth and mortality in adult age. It is also the first study in the field including longitudinal data from age-spans below 50 years. By excluding people born outside Sweden, we were able to create a homogenous study population with respect to seasonally dependent early life exposures as well as country-specific social factors. Further, we had access to information about subjects’ education (a potential confounder) in the experiments: PU. Analyzed the data: PU FG AKEB SC. Wrote the paper: PU AKEB SC.

Generalizing the findings to other parts of the world may not be strictly possible, given the study setting being confined to Sweden, the Swedish climate and its specific seasonal exposures.

Our findings regarding the older age-spans, however, are in line with other reports from the northern hemisphere.

Due to the large number of subjects included in this study, we were able to detect very small risk differences between subjects born in different months that are hard to translate into biological or clinical relevant measures. The relevance of this study could thus be considered as providing clues for the identification of early life exposures of potential public health interest.

In conclusion, this longitudinal population-based study assessed the association between month of birth and mortality in different age-spans in more than 6 million Swedes. Confirming previous findings from the northern hemisphere, spring/summer-born were shown to die sooner than autumn-born in ages 50 years and above. The associations remained after controlling for sex and education. Future studies on the topic should focus on elucidating the mechanisms underlying these observations.

Supporting Information

Figure S1 Excess hazard ratio by month of birth. Including all Swedish-born subjects living in the country on the 1st of January 1991 and excluding subjects without education data (% compared to November). (TIFF)

Acknowledgments

The authors want to thank Prof. Dr. Gabriele Dobhlammer for her kind advice in the beginning of this study and Mr. Gunnar Peterson for organizing the datasets.

Author Contributions

Conceived and designed the experiments: SC PU FG AKEB. Performed the experiments: PU. Analyzed the data: PU FG AKEB SC. Wrote the paper: PU AKEB SC.

References

1. Barker DJ, Osmond C (1986) Infant mortality, childhood nutrition, and ischaemic heart disease in England and Wales. Lancet 1: 1077–1081.
2. Painter RG, Roseboom TJ, Binkley OP (2005) Perinatal exposure to the Dutch famine and disease in later life: an overview. Reproductive toxicology (Elmsford, NY) 20: 345–352.
3. Rinuado P, Wang F (2012) Fetal programming and metabolic syndrome. Annual review of physiology 74: 107–130.
4. Orme JE (1963) Intelligence, Season of Birth and Climatic Temperature. British Journal of Psychology 54: 273–276.
5. Moore SE, Cole TJ, Poikari EM, Sosko BJ, Whitehead RG, et al. (1997) Season of birth predicts mortality in rural Gambia. Nature 388: 434.
6. Vaiserman AM, Voitenko VP (2003) Early programming of adult longevity: demographic and experimental studies. Journal of anti-aging medicine 6: 11–20.
7. Rellföllmann T, Itermann T, Erpen K, Dor M, Felix SB (2011) Is cardiovascular mortality related to the season of birth?: evidence from more than 6 million cardiovascular deaths between 1992 and 2007. Journal of the American College of Cardiology 57: 887–888.
8. Dobhlammer G, Vanpe JW (2001) Lifeexpect depends on month of birth. Proceedings of the National Academy of Sciences of the United States of America 98: 2934–2939.
9. Dobhlammer G (2004) The Late Life Legacy of Very Early Life. Demographic Research Monographs. Heidelberg, Germany: Springer.
10. Ludvigsson JF, Österblad-Ollasson P, Peterson BU., Ekbohm A (2009) The Swedish personal identity number: possibilities and pitfalls in healthcare and medical research. European journal of epidemiology 24: 659–667.
11. Villar J, Belizan JM (1992) The timing factor in the pathophysiology of the intrauterine growth retardation syndrome. Obstetrical & gynecological survey 47: 639–677.
12. Chodick G, Flash S, Deoitch Y, Shalev V (2009) Seasonality in birth weight: review of global patterns and potential causes. Human biology 81: 463–477.
13. Ward WP (1987) Weight at birth in Vienna, Austria, 1865–1930. Annals of human biology 14: 495–506.
14. Rousham EK, Gracey M (1998) Seasonality of low birthweight in indigenous Australians: an increase in pre-term birth or intrauterine growth retardation? Australian and New Zealand journal of public health 22: 669–672.
15. Keller CA, Nugent RP (1983) Seasonal patterns in perinatal mortality and preterm delivery. American journal of epidemiology 118: 689–698.
16. Forsdahl A (1978) Living conditions in childhood and subsequent development of risk factors for arteriosclerotic heart disease. The cardiovascular survey in Finnmark 1974–73. Journal of epidemiology and community health 32: 34–37.
17. Cunnings EM, Fisch CE (2006) Infection, inflammation, height, and longevity. Proceedings of the National Academy of Sciences of the United States of America 103: 498–503.
18. Pacso JA, Wark JD, Carlin JB, Poonahay A-L, Vaidlermin JJ, et al. (2008) Maternal vitamin D in pregnancy may influence not only offspring bone mass but other aspects of musculoskeletal health and adiposity. Medical hypotheses 71: 266–269.
19. Holick MF (2007) Vitamin D deficiency. The New England journal of medicine 357: 266–281.
20. Basile LA, Taylor SN, Wagner CL, Quinones I, Hollis BW (2007) Neonatal vitamin D status at birth at latitude 32 degrees 72: evidence of deficiency. Journal of perinatology: official journal of the California Perinatal Association 27: 568–571.
21. Bodnar LM, Simhan HN, Powers RW, Frank MP, Cooperstein E, et al. (2007) High prevalence of vitamin D insufficiency in black and white pregnant women residing in the northern United States and their neonates. The Journal of nutrition 137: 447–452.
22. Greaham O, Tare M, Parkinson HC, Morley R, Porrillo ER, et al. (2010) Maternal vitamin D deficiency leads to cardiac hypertrophy in rat offspring. Reproductive sciences (Thousand Oaks, Calif) 17: 168–176.
23. Nachman-FAM, Cecchino TC, Agala MB, Macduned-de Lacera CA (2012) Maternal vitamin d deficiency delays glomerular maturity in il and 5f offsprings. PloS one 7: e14176.
24. Krishnaveni G V, Vena SA, Winter NR, Hill JC, Noonan K, et al. (2011) Maternal vitamin D status during pregnancy and body composition and cardiovascular risk markers in Indian children: the Mysore Parthenon. American journal of Clinical Nutrition: 629–633. doi:10.3945/ajcn.110.009211.
25. Crouser SR, Harvey NC, Inskip HM, Godfrey KM, Cooper C, et al. (2012) Maternal vitamin D status in pregnancy is associated with adiposity in the offspring: findings from the Southampton Women’s Survey. The American journal of clinical nutrition 96: 57–63.
26. McGrath JJ, Eyles DW, Pedersen CB, Anderson C, Ko P, et al. (2010) Neonatal vitamin D status and risk of schizophrenia: a population-based case-control study. Archives of general psychiatry 67: 889–894.
27. Mirzaei F, Michels KB, Munger K, O’Reilly E, Chitnis T, et al. (2011) Gestational vitamin D and the risk of multiple sclerosis in offspring. Annals of neurology 70: 30–40.
28. van der Meer IM, Karamali NS, Boeke AJP, Lips P, Middelkoop BJC, et al. (2006) High prevalence of vitamin D deficiency in pregnant non-Western women in The Hague, Netherlands. The American journal of clinical nutrition 84: 350–3; quiz 468–9.
29. Sachan A, Gupta R, Das V, Agarwal A, Awasthi PK, et al. (2005) High prevalence of vitamin D deficiency among pregnant women and their newborns in northern India. The American journal of clinical nutrition 81: 1060–1064.
30. Bobak M, Gjonca A (2001) The seasonality of live birth is strongly influenced by socio-demographic factors. Human reproduction (Oxford, England) 16: 1512–1517.
31. Kihlbom M, Johansson SE (2004) Month of birth, socioeconomic background and development in Swedish men. Journal of biosocial science 36: 561–571.
32. OECD (2008) Education at a glance. Available: http://www.oecd.org/education/highereducationandadultlearning/41284038.pdf. Accessed 4 October 2012.
33. Sirin SR (2005) Socioeconomic Status and Academic Achievement: A Meta-Analytic Review of Research. Review of Educational Research 75: 417–453.
34. Socialstyrelsen (2011) Dödsorsaker 2010– Causes of Death 2010. Stockholm. Available: http://www.socialstyrelsen.se/publikationer2011/2011-7-6. Accessed 26 September 2012.
35. Socialstyrelsens statistikdatabas - Dödsorsaksstatistik (n.d.). Available: http://192.137.163.49/dsb/dor/ resultat.aspx. Accessed 5 September 2012.