Birth Month Mortality Puzzles in Norway

Iliana V. Kohler* Hans-Peter Kohler†

September 21, 2007

Abstract

We analyze how birth month and seasonality of births are associated with health and mortality above age 50 in Norway. Utilizing the geographic, climatic and socioeconomic diversity of Norway, we investigate possible pathways linking birth month to mortality at older ages. In particular, we investigate whether birth month effects in mortality and health operate trough social mechanisms such as relative age class effects (i.e., educational differences related to relative age within the school cohort). The analyses use data from the Norwegian population register that provides detailed information about demographic and socioeconomic characteristics of the cohorts born prior to 1965. Our results show that Norway is characterized by a strong seasonal pattern in births. We estimate strong association of birth month with mortality for the cohorts born between 1900 and 1914, but only for the southern and eastern part of the country. Controlling for completed level of education does not alter this pattern suggesting that birth month effects do not reflect differences in relative age class. The geographic pattern of birth month effects in mortality in Norway suggests that environmental differences such as exposure to infectious diseases may explain the association of birth month with health and mortality in late life.

Additional analyses, yet to be completed, will utilize the detailed information on causes of death, historical patterns on infant mortality and climatic data to further investigate birth month mortality patterns in Norway.

Preliminary version

1 Introduction

The hypothesis that a person's month or season of birth has important consequences on events or outcomes, occurring—often decades—later during adult or even old age, is intriguing and has been the focus of investigation across different disciplines. Epidemiological studies, for example, extensively document the association of birth month with diseases of the mental and nervous system

*Postdoctoral Fellow and Research Associate, Population Studies Center, University of Pennsylvania, 3718 Locust Walk, Philadelphia, PA 19104-6299, USA; *Email:* iliana@pop.upenn.edu, *Phone:* (215)-898-7990, *Fax:* (215)-898-2124.

†Professor of Sociology, 3718 Locust Walk, University of Pennsylvania, Philadelphia, PA 19104-6299, USA; *Email:* hpkohler@pop.upenn.edu, *Homepage:* http://www.ssc.upenn.edu/∼hpkohler.

such as schizophrenia (Davis et al. 2003), autism (Ticher et al. 1996), anorexia (Waller et al. 2002), Parkinson's disease (Mattlock et al. 1988), epilepsy (Procopio and Marriott 1998), or multiple sclerosis (Miura 1987). In economic and sociological research, birth month has been associated with performance at school (Helsen et al. 2005; Miller and R. 1967; Thompson et al. 2004) or other outcomes later in life such as years of completed education or wages (Plug 2001). In this context, the effect of birth month has been linked to differences in the relative age and the resulting relative advantages older individuals accumulate over time compared to their younger cohort mates. For example, students who are oldest in the class attain almost a year more education than the youngest and as a result have higher wages later in life (Plug 2001).

The focus on birth month effects in demography has been twofold. Demographers have extensively documented the relatively stable seasonal patterns of births across time and regions (Doblhammer et al. 2000; Lam and A. 1994; Lam and Miron 1991; Rogers and Udry 1988) and linked these patterns to behavioral, social or economic differences across places and populations. In addition, several attempts have been made to explain the seasonality of births by climatic and photoperiod differences during the year or across time (Cummings 2002, 2003, 2007; Lam and Miron 1996).

Recently, several studies have linked birth month to mortality and differences in life span (Doblhammer 1999, 2004; Doblhammer and Vauel 2001; Rau 2007). These studies have demonstrated a very strong association of birth month with the risk of death—individuals born in late fall and winter (October-December) live longer than those born in the spring and early summer (April-June). This association is independent of the seasonal distribution of deaths or associated social differences. Moreover, the reverse pattern has been found in the Southern hemisphere (Doblhammer 2004). Doblhammer et al. (2005) have also shown that the birth month effect persist for supercentenarians, where it is generally believed that survival to these very old ages is to a large extent driven by genetic factors (Herskind et al. 1996).

Doblhammer (2004) provides a more general interpretation for the association of birth month with mortality. Namely, birth month measures variations in the critical environment during pregnancy and early infancy such as seasonal nutritional variations, and thus reflects differences in risk factors that imprint on the early physiological development of the fetus and the small child. Differences in the risk of death by birth month are small, but nevertheless persistent and important to understand since these effects are central to our understanding of how early-life conditions affect late life outcomes. In particular, the following pathways may link birth month to health in late life: *a)* birth month reflects nutritional differences in the in-utero environment; b) birth month reflects differential exposure to infectious diseases either in-utero or in early infancy; *c)* birth month may operate through social mechanisms such as relative age class effect.

The goal of this paper is to shed light on these three possible pathways linking birth month to late life health by using data from Norway. Norway represents an interesting case to study patterns in birth month seasonality and its association with mortality for several reasons. First, this is the geography of the country and the resulting climatic and photoperiod differences across regions. The country shares the same latitude as Alaska, Greenland and Siberia, and between the southernmost point, Lindesnes, and the northernmost point, North Cape, there is a span of 13 degrees latitude which is the same span as from Lindesnes to the Medetirenean Area (see for example *http://www.met.no/english/climate/index.html*). Given its long geographical stretch, the country is characterized by large climatic variations and differences in light intensity across regions. The most extreme example is the North that has midnight sun during the summer and no light in the winter months. In addition, the mountainous topography of Norway creates large climatic variations in relatively short distances. These country's characteristics are associated with substantial nutritional, social, economic and behavioral differences across regions. We hypothesize that these regional variation will result in large differences in the seasonality of births in Norway and the association of month birth with mortality. In particular, we hypothesize that the largest variations will be observed in the North of Norway, and the amplitude of seasonal variation will decrease when moving to the Southern regions.

Historically and at present as well, Norway was characterized by a great economic disparity across regions with the South representing the economically better developed and more urbanized areas. In contrast, the North is less populated, had higher mortality, especially infant mortality (Thorvaldsen 2002), and is poorer than the remaining parts of the country. If the effect of birth month on mortality reflects in fact differences in nutritional status and nutritional deficiencies, we hypothesize that its effect would be strongest in the worse-off parts of the country (i.e., the North) that were historically much more dependent on seasonal nutritional patterns.

If birth month reflects relative age class differences, we would expect that its association with the risk of death will weaken or even disappear once we control for education in the models. We will also expect differences in the mean years of education by birth month. The Norwegian data allow to test this hypothesis.

Last, to the author's best knowledge, seasonality of births and the effect of birth month on the risk of death have not been studied in Norway.

2 Data and methods

2.1 Data

The present analyses are based on data from the Norwegian Population Register that includes individual-level information about everyone who has lived in Norway after 1960. The register provides detailed information about the demographic and socioeconomic characteristics of all men and women born after 1965. In order to complement the available data for the older cohorts born before 1960, a personal identification number was used to link this register to other sources of information. For instance, data on county of birth for those born before 1960 and their completed

Table 1: Summary statistics for cohorts born 1900-1914 included in the present study.

	Men	Women
Total number of observations (1971)	272,014	299,569
Emigrated between 1971-2003	200	162
Deaths (1971-2003)	262,652	273,036
Alive (end 2003)	9,162 (3%)	26,371 (8.8%)

education were obtained from the 1960 and 1970 Population Censuses and Statistics Norway's Education Register.

The focus of the present analyses is on cohorts born between 1900 and 1914 in Norway. These cohorts have been followed up from ages 50-65 years[1] until the end of 2003, when especially for the oldest cohorts born in the beginning of the 20th century we have observed more or less their completed mortality experience.

The sample includes only men and women born in Norway. Those, who were born outside of the country, but migrated later to Norway, were excluded from the data. In addition, the analyses are conditional on survival to the end of the year 1970 when the individuals considered in the present analyses were 55 to 70 years old.[2] The analyses for men are based on 272,014 individuals who were alive in the beginning of 1971. Of these, 262,652 were dead at the end of 2003, 200 have emigrated and only 9,192 (3%) were alive at the end of the observation period. For women, the respective numbers as following: 299,569 women born between 1900-1914 were alive in the beginning of 1971 and included in our analysis. Of those, only 26,371 (8.8%) survived until the end of the observation period in 2003, 162 have emigrated and 273,036 women have died (see Table 1).

Part of our analyses focuses on regional differences in the seasonality of births and the birth months effects on mortality. We define five regions based on the municipality of birth—East, South, West, Central and North, and the regional devision that is used further in this paper is depicted in Figure 1.

[1]This corresponds to the age range these cohorts had when the Norwegian Population Register was introduced in 1965.

[2]This requirement is somewhat arbitrary and based on the fact that we use information on education from the 1970 Population Census which implies that the individuals had to be alive at Census day. Alternatively, we can condition the analyses on survival to 1965, when the Population register was established. In this latter case however, we will not have a detailed educational information as the once obtained from the 1970 Census.

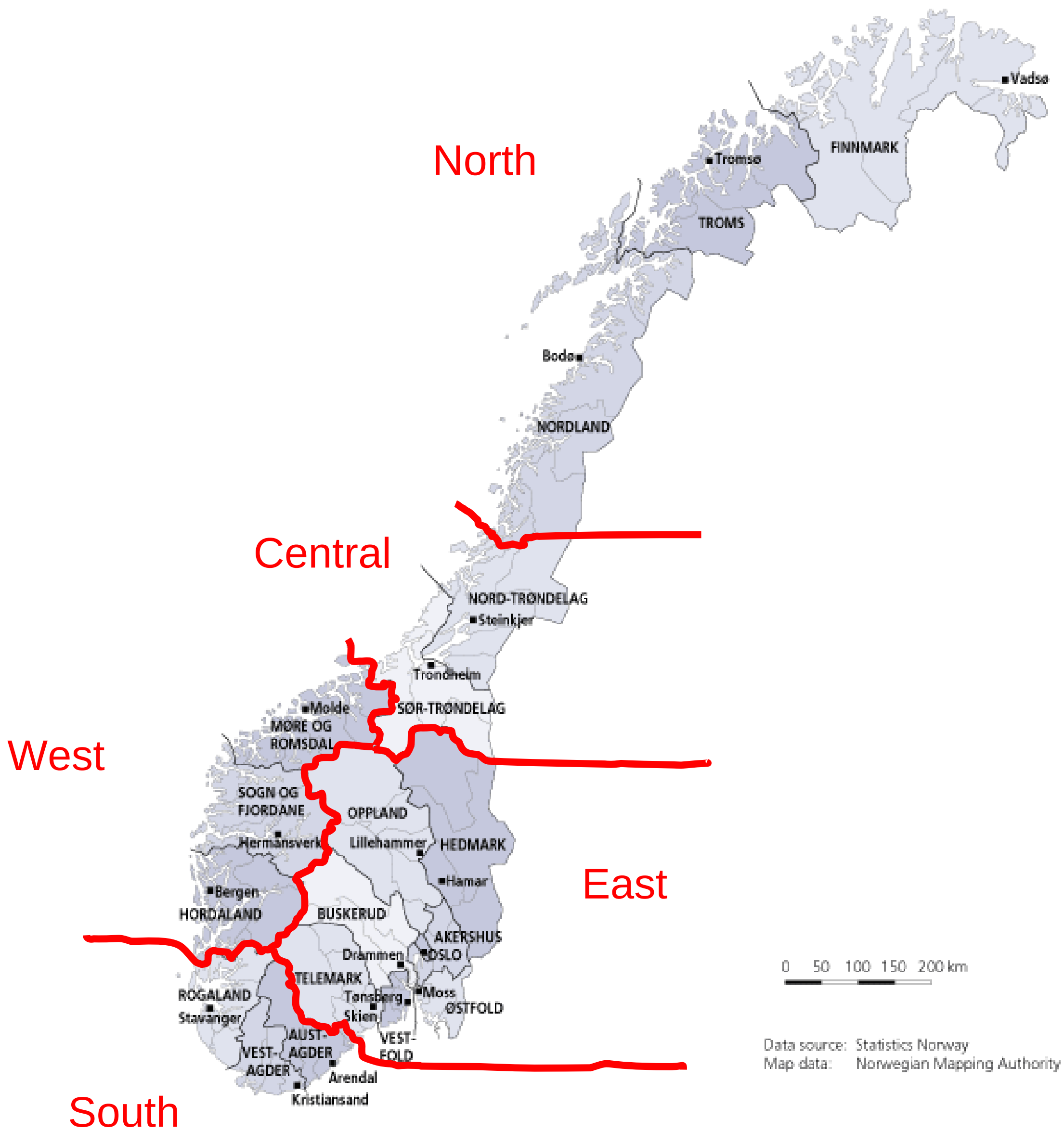

Figure 1: Definition of regions in Norway. Map source: Statistics Norway. Map is available at: http://www.ssb.no/english/yearbook/2005/kart/fylkesinn.gif. The regional boundaries are drawn by the author.

2.2 Methods

Existing research, (e.g. Doblhammer 2004), has frequently analyzed age-specific mortality rates for cohorts defined by month of birth by applying different partially non-standard statistical approaches, where the choice of the method is in part determined by the limitation of the data used in these previous studies. In this paper, we adopt the uniform event-history approach that optimally uses the available cohort data for Norway and properly adjusts the analyses for left and right censoring. Besides estimating the effect of birth month on mortality, the event-history approach allows also including the month-of-year period effects and controlling for the effects of other confounding demographic and socioeconomic characteristics such as education.

In particular, we estimate a standard event-history model where the baseline mortality hazard is specified parametrically by a Gompertz function. The Gompertz model is appealing in the present analysis for several reasons. It has been widely shown that the Gompertz model describes well the age-specific mortality patterns at older ages where the risk of death increases exponentially with age. Exploratory analyses (not presented here) have confirmed that the age-specific death rates of the Norwegian cohorts investigated in this paper follow a Gompertz function and the model provides a good fit to the Norwegian data.

In addition, using the parameter estimates obtained from the model, we can calculate age-specific death rates by various demographic and socioeconomic characteristics such as sex, month of birth and/or education. These rates in turn can be converted to age-specific probabilities of dying and can then be used to calculated various life table functions such as remaining life expectancy at age 50 and over.[3]

Rather then choosing a specific birth month as a reference category, we impose a linear constraint on the model specification so that the sum of the coefficients pertaining to the effects of birth months equals zero. Hence, the birth month coefficients reflect the deviation of the mortality level observed for a specific birth month from the cohort average.

We also perform a post-estimation test of whether the mean effect from the months March, April, May and June (i.e., late spring—early summer) is equal to the mean effect of the months September, October, November and December (i.e., late fall—early winter). That is, we test whether the risk of death for those born in the spring months is statistically different from the risk of death observed for those born in the fall/early winter months.

We estimate several sets of these event-history models in which we first include only the effects of birth months and birth cohorts, followed by a model in which we control in addition also for the effects of current month of calendar year (i.e., period effects); as last in addition to all previous variables we include level of completed education. All models are estimated sex-specific, for the entire country or by region.

[3]This has not been done at the current stage of the analysis, thus results cannot be presented.

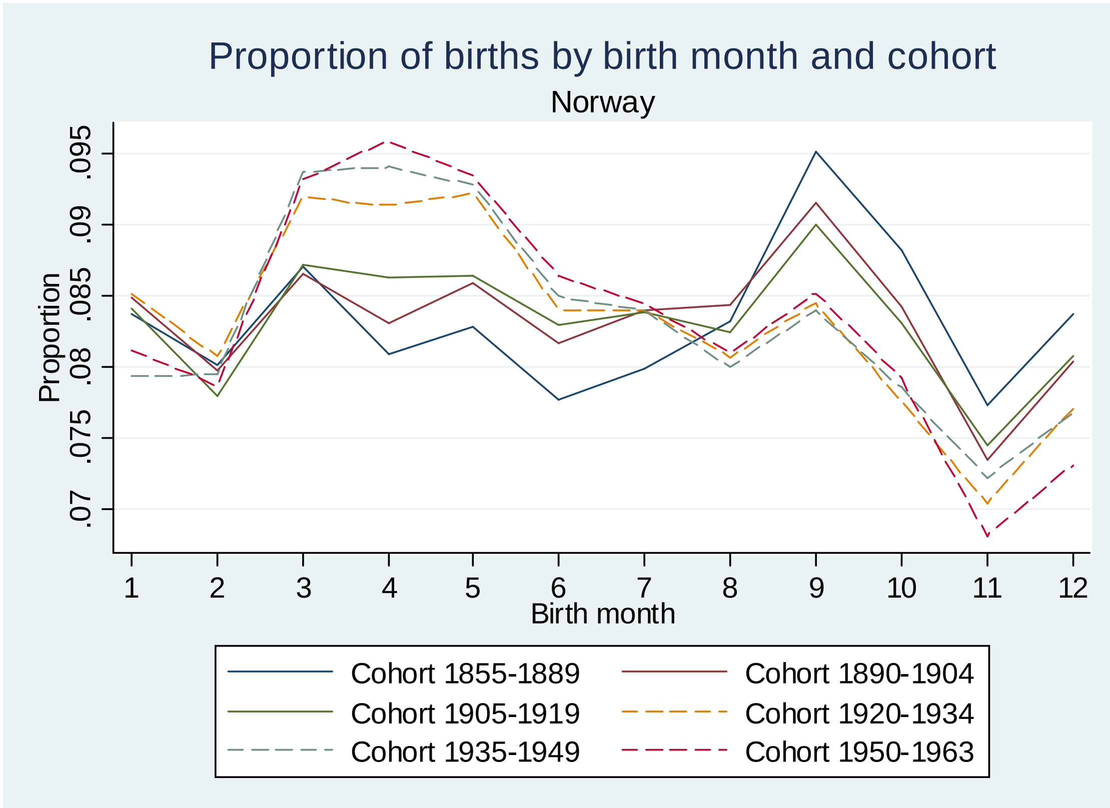

Figure 2: Proportion of births by birth months and cohorts, Norway.

3 Seasonality of births in Norway

In order to draw a preliminary picture of seasonal patterns in the number of births in Norway, we first focus on the analyses of seasonality of births and its variation across regions and time. Even though there is no clear agreement what its underlying causes are, it has been often emphasized that these patterns reflect existing climatic, biological and/or socioeconomic differences across regions and people. Norway is characterized by substantial variation in these latter factors. Thus, it is of a particular interest to investigate whether systematic similarities and differences in seasonal birth patterns persist across geographic regions and to which extent they mirror patterns observed in other countries.

Figure 2 shows the proportion of births by birth month and 15-years birth cohorts for the entire country. These analyses are based on data for all individuals born between 1855 to 1963 in Norway. The estimates combine both sexes as preliminary analyses have shown no differences by sex.

Norwegian birth cohorts born before 1920 are characterized by a peak in the number of births in the fall months, in particular in September. In sharp contrast to this, younger cohorts born after 1920 experience a peak in the number of births in the spring months, with a second and much more

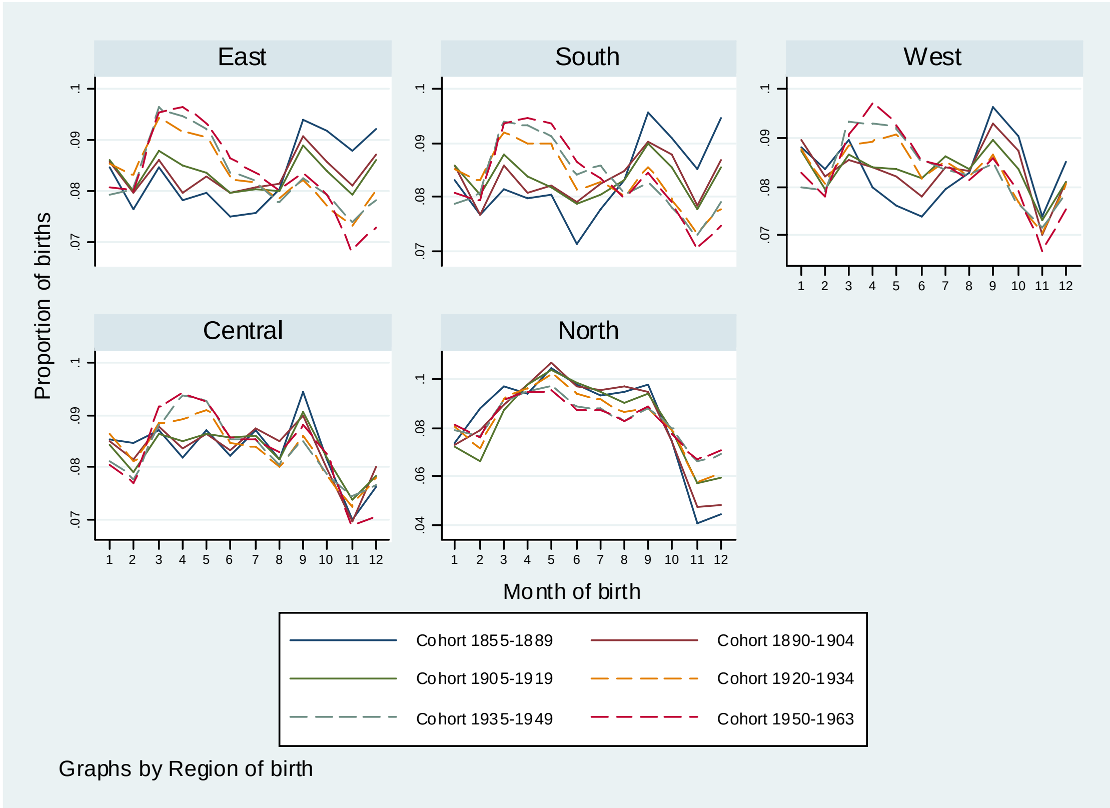

Figure 3: Proportion of births by birth months, birth cohorts and regions.

modest peak in September. This shift in the seasonal patterns of births over time is striking given the fact that the variation in the number of births by season, time and place shows relatively stable patterns (Rogers and Udry 1988). In contrast to the observations made in other countries (Lam and A. 1994), Norway underwent a cohort change in the seasonal patterns of births and switched from the U.S. pattern with a fall peak and April-to-May low to the European pattern with a spring peak.

Figure 3 shows the variation in seasonal fluctuations in births by regions. The cohort trends described for the whole country, are observed across regions as well, with the exception of the North. In contrast to all other parts of the country, the Northern region did not experience a switch in cohort patterns in the seasonality of births historically. Seasonality of births in the North of Norway, is remarkably stable by birth cohorts, and is characterized by only a modest peak in May and even a smaller peak in September. Two main features distinguish the North from other parts of the country. First, although seasonality of births is only modestly pronounced, the North seems to follow historically the European pattern rather than switching later into it as the remaining parts of Norway did. Second, the North region resembles most closely the patterns observed for the State of Washington, U.S., and Canada that are characterized by relatively constant number of births from March to July Lam and A. (1994).

4 Birth Month Mortality in Norway

Figure 4 shows the effects of birth month on male mortality for the cohorts born between 1900-1914. These analyses are based on models that in addition to estimating the effect of birth month control also for current month of the year (period effect) and 5-years birth cohorts. In this figure, we also compare whether the birth month effect changes once level of education is considered as a covariate in the models. The upper left graph in Figure 4 presents the results for the entire country, while the remaining graphs show the regional variation in the birth month effects across the five regions we defined for this analysis.

The pattern depicted in the upper left graph indicates that in Norway as a whole country birth month is associated with mortality in the way it has been shown already in previous studies. In particular, men born in May and June have higher risk of death compared to the average mortality observed during the year. Moreover, controlled for education, the statistical significance of this effects and the depicted pattern remain. In addition, we have tested whether the difference in mortality between those born in the spring (March to June) and those born in the fall/early winter months (September to December) is statistically significant and the test confirmed that men born in the spring have statistically higher risk of death than the fall-born (see Table 5).

Similar pattern in the birth month effects has been observed for the East region that includes the Oslo area. In particular, the estimates indicate that men born in this region in April have higher risk of death than the average observed for the year, while the significance for this effect for the months may and June is borderline significant. Once education is included in the model, only men born in June have statistically higher risk of death than the average mortality observed across all months in the year. In the East region, men born in the spring have also statistically higher risk of death than men born in the fall.

In contrast to this, in none of the other four regions we were able to estimate statistically significant (at the 5%-level) birth month effects on mortality. The patterns of the birth month effects for the South, West, Central and North regions are quite erratic and there is no significant difference between those born in the spring and those born in the fall/early winter months.

With few exceptions, the estimates for women depicted in Figure 6 are similar to the results shown for men. In Norway as a whole, only women born in September have statistically lower risk of death than the average mortality observed during the year. In addition, similar to men, women born in the spring have higher risk than those born in the fall and this difference is statistically significant at the 5%-level (see Table 5. The same pattern can be found also in the Eastern region. In this part of the country, however, the risk of death for women born in May is higher than the observed average during the year, while women born in September have statistically lower risk of death than the average mortality. The only other region, where birth month has statistically

Figure 4: Birth month effects on mortality for men, Norway and five Norwegian regions.

Table 2: Summary of tests for significant birth month effects

Men, 1900-1914

Test	Norway		East		South		West		Central		North	
	No educ	With educ	No educ	With educ	No educ	With educ	No educ	With educ	No educ	With educ	No educ	With educ
Significant effect of birth month at 5%-level	May, June	May, June	April; May, June?	June	NS	NS	NS	NS	NS	NS	June	NS
Spring months = Fall months	***	***	***	***	NS	NS	NS	NS	NS	NS	NS	NS

Women, 1900-1914

Test	Norway		East		South		West		Central		North	
	No educ	With educ	No educ	With educ	No educ	With educ	No educ	With educ	No educ	With educ	No educ	With educ
Significant effect of birth month at 5%-level	September	September	May, September	May, September	NS	NS	August	August	NS	NS	NS	NS
Spring months = Fall months	***	***	***	***	NS	NS	NS	NS	NS	NS	NS	NS

Figure 5: Summary of tests for significant birth month effects for Norway and five Norwegian regions.

different effect compared to the average mortality is the West, where women born in August have higher risk of death compared to the average mortality during the year. In all other parts of the country, no significant birth month effects could be found, independently of whether control for education was included or not in the models.

5 Discussion

The current paper draws a broad picture of how birth month is associated with demographic outcomes such as fertility (i.e., seasonality of births) and mortality in Norway. Our results show that Norway is not an exception from the global picture and there is a strong seasonal pattern in the distribution of births in the country. What distinguishes Norway from other parts of the world is the cohort change in this pattern that occurred in the 1930s. The country underwent a dramatic shift in the seasonal distribution of births switching from the U.S. pattern with a peak in September to the European pattern with a peak in the Spring. In contrast to our expectations, this change in the fertility behavior did not occur in the far North of the country. Moreover, the northern region of Norway is characterized by very modest seasonal patterns in the distribution of births.

Previous research has associated the seasonality of births and its variation across place with environmental factors such as temperature and photoperiod. In addition, researchers have linked the seasonal variation in the number of births to differences in marriage patterns, holidays, temporal migration, economic factors such as agricultural cycles, etc. (Lam and A. 1994). The most reasonable explanation for the time trend in the seasonality of births in Norway is related to economic changes in the country, and in particular to the shift from agriculture as the primary source of living and employment to a heavier industrialization of the country, especially in the southern regions. Agriculture is associated with strong seasonal pattern of heavy work concentrated within short period of time (summer—fall months). Assuming that people increased the frequency of intercourse at the end of the agricultural work cycle, and conditional on the time lag between intercourse and pregnancy, the September peak of births for the older cohorts can be easily explained. With progressing industrialization in the country people's work became less depended on seasons and thus it may have resulted in a change of intercourse patterns reflected in the change of the seasonal distribution of births. Why this provides reasonable explanations for the cohort switch in parts of the country, changes in behavioral and economic factors cannot explain why the North behaves differently and puts a real puzzle for the researchers. Interestingly enough, the most pronounced patterns in seasonality of births is found in places with extreme changes in temperature and with extreme latitude. This suggests that it is worth to further explore to which extend the seasonal patterns observed in the distribution of births are related to differences in temperature for example. Considering environmental factors may help to solve the puzzle observed in the North.

Birth month is associated with mortality in Norway for the cohorts born between 1900 and 1914. In contrast to our expectations, however, we find this effect being statistically significant

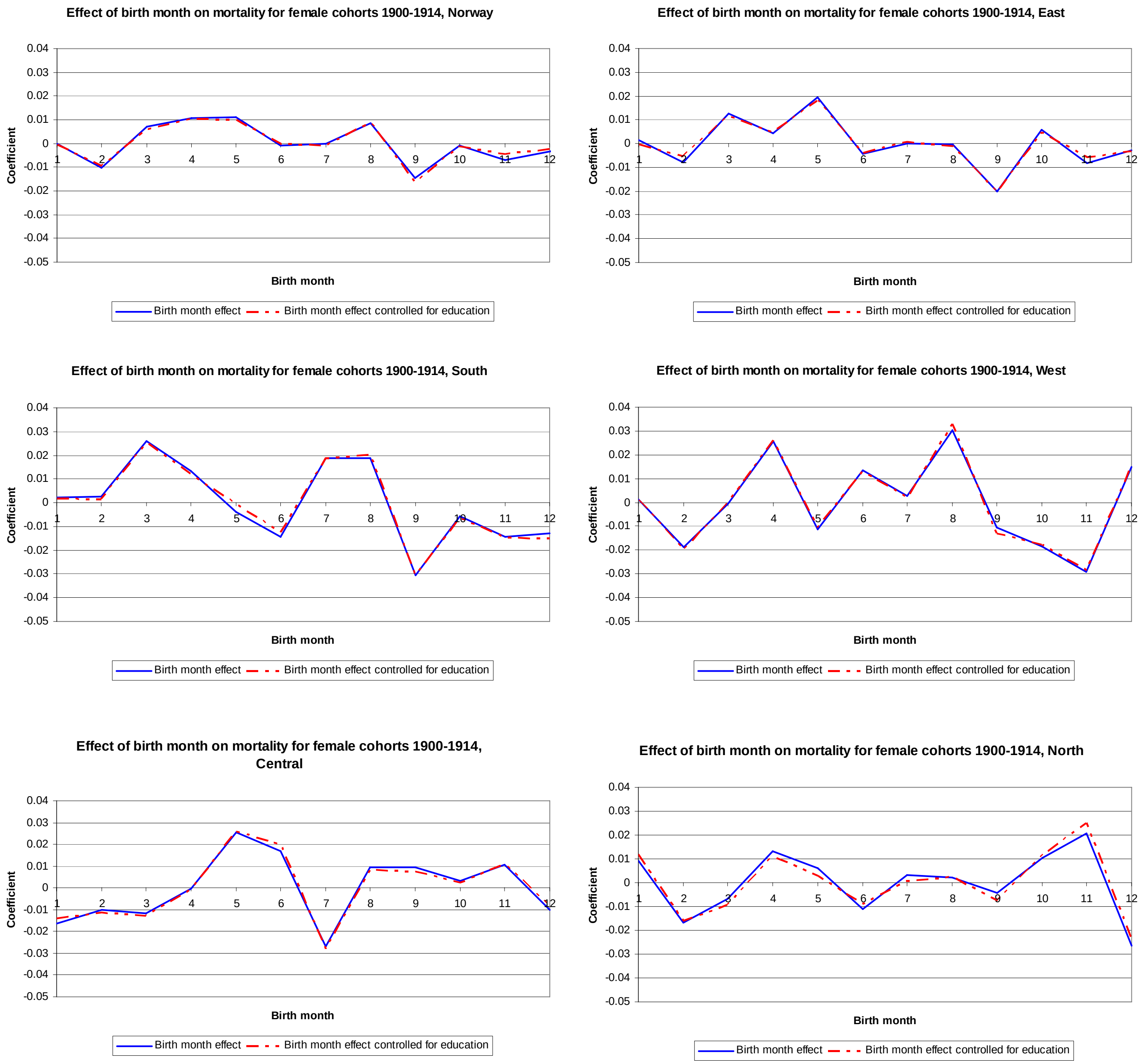

Figure 6: Birth month effects on mortality for women, Norway and five Norwegian regions.

only in the eastern and southern part of the country. In particular, we find no association of birth month with mortality in the North, a region that historically, economically, and geographically differs substantially from the rest of the country. This finding questions whether the effect of birth month can be explained through differences in the nutritional patterns of mothers by season. We anticipate that nutritional patterns in the North in the beginning of the 20th century were much more seasonably dependent compared to the more industrialized south parts of the region. What however distinguishes the North is the low level of urbanization, especially in the first half of the 20th century and the much more sparsely concentrated population there. Previous research has shown that level of urbanization was associated with the spread of infectious diseases. As a result, we hypothesize that the birth month effect is not related to seasonal differences in nutrition, but to differences in exposure to infectious diseases during pregnancy. (Crimmins and Finch 2005; Finch and Crimmins 2004) for example have recently shown early-life infectious effects on old-age mortality, which provides indirect support for our hypothesis. That is, our results do not reject that it is the early environment that imprints on adult and old age mortality, but it suggest a different mechanism of how birth month may be associated with the risk of death. Future research in this context will focus on the differences by causes of death, infant mortality to find an additional support for this hypothesis.

Last, including control for education did not alter our estimates and thus contradicts the hypothesis that birth month reflects relative age differences. This hypothesis however is worth investigating further as we find some indication that those born in the fall months tend to have slightly higher level of education than those born in th spring.

References

Crimmins, E. M. and C. E. Finch (2005). Infection, inflammation, height, and longevity. *Proceedings of the National Academy of Sciences 103*(2), 498–503.

Cummings, D. R. (2002). The seasonality of human births, mealtonin and cloud cover. *Biological Rhythm Research 33*(5), 521–559.

Cummings, D. R. (2003). The influence of letitude and cloud cover on the seasonality of human births. *Social Biology 50*, 23–41.

Cummings, D. R. (2007). Additional confirmation for the effect of environmental light intensity on the seasonality of human conceptions. *J.biosoc. Sci. 39*, 383–396.

Davis, G., J. Welham, D. Chant, E. F. Torrey, and J. McGrath (2003). A systematic review and meta-analysis of Northern hemisphere season of birth studies in schizophrenia. *Schizophrenia Bulletin 29*(3), 587–593.

Doblhammer, G. (1999). Longevity and month of birth: Evidence from Austria and Denmark. *Demographic Research* [online available at http://www.demographic-research.org] *1*(3).

Doblhammer, G. (2004). *The late life legacy of very early life*. Berlin: Springer Verlag.

Doblhammer, G., J. L. Rogers, and R. Rau (2000). Seasonality of birth in nineteenth-and twentieth-century Austria. *Social Biology 47*(3-4), 201–217.

Doblhammer, G., R. Scholz, and H. Maier (2005). Month of birth and survival to age 105+: Evidence from the age validation study of German semi-supercentenarians. *Experimental Gerontology 40*, 829–835.

Doblhammer, G. and J. W. Vauel (2001). Lifespan depends on month of birth. *Proceedings of the National Academy of Science 98*(5), 2934–2939.

Finch, C. and E. Crimmins (2004). Inflammatory exposure and historical changes in human lifespan. *Science 305*, 1736–1739.

Helsen, W. F., J. Van Winckel, and A. M. Williams (2005). The relative age effect in youth soccer across Europe. *Journal of Sports Sciences 23*(6), 629–636.

Herskind, A. M., M. McGue, N. V. Holm, T. I. A. Sorensen, B. Harvald, and J. W. Vaupel (1996). The heritability of human longevity: A population based study of 2872 Danish twin pairs born 1870–1900. *Human Genetics 97*(3), 319–323.

Lam, D. A. and M. J. A. (1994). Global patterns of seasonal variation in human fertility. *Annals of the New York Academy of Sciences 709*, 9–28.

Lam, D. A. and J. A. Miron (1991). Seasonality of births in human populations. *Social Biology 38*, 51–78.

Lam, D. A. and J. A. Miron (1996). The effects of temperature on human fertility. *Demography 33*(3), 291–305.

Mattlock, C., M. Marmot, and G. Stern (1988). Could Parkinson's disease follow intra-uterine influenza? A specilative hypothesis. *Journal of Neurology, Neurosurgery and Psychiatry 35*, 753–756.

Miller, D. and N. R. (1967). Entrance age and school success. *Journal of School Psychology 6*, 47–90.

Miura, T. (Ed.) (1987). *Seasonality of Birth. Progress in Biolmeteorology*, Hague. SPB Ascademic Punblishing.

Plug, E. J. S. (2001). Season of birth, schooling and earnings. *Journal of Economic Psychology 22*, 641–660.

Procopio, M. and P. K. Marriott (1998). Seasonality of birh in epilepsy. a Danish study. *Acta Neurologica Scandinavica 98*, 297–301.

Rau, R. (2007). *Seasonality in human mortality: a demographic approach*. Berlin: Springer Verlag.

Rogers, J. L. and J. R. Udry (1988). The season-of-birth paradox. *Social Biology 35*(3-4), 171–185.

Thompson, A. H., H. Roger, R. Barnsley, and J. Battle (2004). The relative age effect and the development of self-esteem. *Educational Research 46*(3), 313–320.

Thorvaldsen, G. (2002). Rural infant mortality in Nineteeth Century Norway. *Hygiea Internationalis : An Interdisciplinary Journal for the History of Public Health 3*(1), 75–113.

Ticher, A., A. Ring, Y. Barak, A. Elizur, and A. Weizman (1996). Circannual pattern of autistic births. reanalysis in three etnic groups. *Human Biology 68*, 585–592.

Waller, G., W. B., C. Potterson, M. Niederman, J. Sellings, and K. e. a. Willoughby (2002). Pattern of birth in adults with Anorexia Nervosa. *Journal of Nervous and Mental Diseases 190*, 752–756.