Changing Seasonal Variation in Births by Sociodemographic Factors: A Population-Based Register Study

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Abstract: Seasonality of births is in some populations strongly influenced by sociodemographic factors. In this study, we analyse the impact of mothers’ sociodemographic characteristics for the seasonal variation in 7,710,955 live births in Sweden between 1940 and 2012. During 1940-1999, Swedish birth rates showed the typical seasonal variation with high numbers of births during the spring, and low numbers of births during the last quarter of the year. However, during the twenty-first century, the seasonal variation in fertility declined so that only minor variation in birth rates between February and September remains. Still, the pattern of low birth rates at the end of the year remains and has even become more pronounced in recent decades. The roles of maternal education, mother’s birth country, parity, and instances where the mother has re-partnered between subsequent births changed during the second half of the twentieth century. The study underlines that in a society with low fertility and efficient birth control, active choices and behaviours associated with an individual’s sociodemographic characteristics tend to matter more for the seasonal timing of childbearing than environmental factors related to the physiological ability to reproduce and cultural-behavioural factors related to the frequency of intercourse.

Keywords: Fertility, Birth seasonality, Socioeconomic factors
Introduction

Almost all human populations exhibit seasonal variation in births. Most European countries show seasonal variation that usually peak in the spring and are the lowest during the last quarter of the year. In contrast, most American states show patterns with high numbers of births during the summer and autumn and low numbers of births during spring. Some countries, such as Israel, Australia, New Zealand, and South Africa show almost no seasonal variation in birth rates (Lam and Miron, 1994; Bronson, 1995). Research has repeatedly found that a child’s month of birth is associated with later outcomes in life, such as those related to health (Reffelmann et al., 2011) and mortality (Ueda et al., 2013).

Although frequently studied, the causes of the seasonal variation are not fully understood. Explanations for human birth seasonality can be grouped into three categories (Ellison et al., 2005): seasonality due to climatological factors (Lam and Miron, 1996), seasonality due to energetic factors (Ellison and Ellison 2009), and seasonality due to social factors (Bobak and Gjonca, 2001; Buckles and Hungerman, 2013; Azcorra et al., 2017). Among the social factors that may influence the seasonal variation in human birth rates, those associated with the probability of intercourse have received the most attention (Udry and Morris, 1967). In many countries, the highest birth rates can be observed around nine months after major secular and religious holidays (Lam and Miron, 1994). Most European countries that celebrate Christmas exhibit a minor peak of births in September (James, 1990). Also, seasonality in marriage has been shown to explain some of the seasonal variation in births (Stolwijk et al., 1996). However, it is likely that the effect of social patterning in the frequency of conception is relatively low in contemporary society due to effective methods of contraception and more deliberate decisions about family planning (Bobak and Gjonca, 2001).
Another set of social factors that have been studied in relation to seasonal variations in births are those that relate to different sociodemographic factors. Several studies have examined the impact of social class on the seasonal variation in births (Pasamanick et al., 1960; Zelnik, 1969; Erhardt et al., 1971; James, 1971; Chaudhury, 1972; Warren and Tyler, 1979; Bobak and Gjonca, 2001; Buckles and Hungerman, 2013; Azcorra et al., 2017). Most of these studies show that the seasonal variation in childbearing differs by the sociodemographic characteristics of the mother. However, most studies rely on aggregated and sometimes quite outdated sources of data. All previous studies built on bivariate analyses, and thus did not control for the potential role of any confounding factors. Additionally, hardly any previous study reports on changes in the seasonal variation in births over time, the main exceptions being a univariate study on Sweden by Cassel (2002) and a parity-specific study on the Netherlands by Haandrikman and van Wissen (2008). The present study contributes to the previous literature by reporting on clear changes over time regarding the impact of four sociodemographic factors in the seasonal variation in childbearing, i.e., those of maternal education, country of birth, parity, and re-partnering.

**Data and Methods**

Data were retrieved from the Swedish multigenerational register, with information on all Swedes born from 1932 onwards, who have been registered as residents in Sweden at any time since 1961. The data contain high-accuracy information on vital events such as childbirths. The information used in the present study includes all Swedish births that occurred between 1940 and 2012, for which the biological mother and father were known. Biological parents were identified for 90% of children born in the 1940 cohort, 95% in the 1945 cohort, and more than 99% for children born in 1950 onwards. In total, 7,710,955 live births were included in the analyses. The main independent variables were the mother’s
education, the mother’s country of birth, parity, and if the mother had re-partnered between previous births. Three categories of educational attainment were used: compulsory schooling, upper secondary education, and post-secondary education. Parity was categorised into three groups of birth orders: first birth, second birth, and third or higher order births. The mother’s country of birth included a dichotomous measurement that indicated whether the mother was Nordic-born or came from any other country in the world. The re-partnering variable measured whether the mother had re-partnered between consecutive births. All four sociodemographic factors were measured at the time of the birth. To analyse changes by sociodemographic factors over time, the calendar years that were studied were divided into four groups: 1940-1959, 1960-1979, 1980-1999, and 2000-2012. In all analyses, the mother’s age was also included as a control variable. When analysing the role of re-partnering, only women with at least one prior delivery were included.

Multinomial logistic regressions were used to calculate predicted probabilities of giving birth in each calendar month of a year. The results are reported as the ratio of observed versus expected probabilities of childbirth for each month. Each month's number of days was taken into consideration (February is assumed to have 28.25 days on average). Using multinomial logistic regression rather than simply comparing expected and observed numbers of births, allows for multivariate analyses with the controls for potentially confounding factors.

**Results**

The differences between the expected and observed probability of childbearing for each month by the four calendar periods are shown in Table I and Figure 1. The same differences for women of different sociodemographic characteristics are shown in Tables II-V and Figures 2a-5d. For most calendar periods and all sociodemographic categories we find some
seasonal variation in childbearing. However, the seasonal variation is most pronounced for women with certain specific characteristics, and has, in most cases, changed its pattern over time.

Between 1940 and 1999, most births took place during the spring and the least between October and December. However, during the most recent period of the twenty-first century, the seasonal variation was visibly reduced, with relatively small variation in outcomes over the months between February and September. Still, the pattern of low birth rates during the end of the year remained and even become more pronounced from the 1980s onwards. During the first four decades under study, a clear increase in the number of births occurred in September. However, this Christmas effect vanished in the 1980s (Table I and Figure 1).

Between 1940 and 1979, there were only minor differences in the seasonal variation in births between mothers with different education attainment. During the 1940s and 1950s, the pattern of higher birth rates in the spring and fewer during the second half of the year was somewhat more pronounced among mothers with post-secondary education (Table II, Figures 2a and 2b). During 1980 to 1999, mothers with upper-secondary education or higher education had a more pronounced seasonal variation than mothers with low education level. During the 2000s, the seasonal variation declined for mothers of all educational levels, although the decline in birth rates during the last quarter of the year became even more pronounced among mothers with upper secondary or higher education (Table II, Figure 2c and 2d).

During the first four decades we study, differences in seasonal variation between Nordic-born and mothers from other countries were relatively small, and both groups showed high birth rates in the spring and lower rates during the second half of the year (except September) (Table III, Figure 3a and 3b). From the 1980s onwards, mothers from other
countries than the Nordic ones had only minor seasonal variation in childbirths. During the same time, the low birth rates in November and December were strongly accentuated among Nordic-born mothers (Table III, Figure 3c and 3d).

During 1940 to 1979, mothers of third and higher order births showed the least seasonal variation, while mothers of first and second order births showed more pronounced patterns of seasonality. From the 1960s onwards, mothers with second births had the most pronounced seasonal variation in childbearing. From the 1940s and throughout the study period, the seasonal variation among first time mothers declined steadily, and from the 2000s, the seasonal variation for this groups of mothers was quite minor (Table IV and Figures 4a-4d).

During the first two decades under study there were no meaningful differences in seasonal variation between mothers with the same or a new co-parent for subsequent births (Table V and Figure 5a). However, during the 1960s and 1970's, mothers who had not re-partnered between subsequent births exhibited much clearer seasonal variation than mothers who had re-partnered between previous births. In the 1980s and 1990s, the difference between re-partnered and other mothers remained intact, although at a somewhat reduced level. Also, in the twenty-first century, the differences between the seasonal variation for mothers who had re-partnered and those who had not done so were smaller than those seen in the 1960s to 1990s. We note that the reduction in the differences between re-partnered and other mothers is primarily driven by the weakened seasonal variability of mothers not re-partnering. The seasonal variation among re-partnered mothers was relatively small during the entire study period.
Table I. Observed/expected probabilities of births by month and years.

| Month of birth | 1940-1959 | 1960-1979 | 1980-1999 | 2000-2012 |
|----------------|-----------|-----------|-----------|-----------|
| January        | 93        | 96        | 98        | 96        |
| February       | 100       | 104       | 106       | 102       |
| March          | 110       | 113       | 112       | 104       |
| April          | 113       | 117       | 114       | 107       |
| May            | 110       | 109       | 107       | 105       |
| June           | 104       | 102       | 105       | 105       |
| July           | 100       | 97        | 102       | 107       |
| August         | 95        | 94        | 99        | 104       |
| September      | 101       | 99        | 99        | 102       |
| October        | 93        | 93        | 90        | 96        |
| November       | 90        | 89        | 85        | 88        |
| December       | 92        | 87        | 83        | 83        |

Adjusted for each month’s number of days and mother’s age, education, country of birth, and parity.

Figure 1. Seasonal variation in births by years
Table II. Observed/expected probabilities of births by month, years, and mothers education.

| Month of birth | 1940-1959 | 1960-1979 | 1980-1999 | 2000-2012 |
|---------------|-----------|-----------|-----------|-----------|
|                | Obs/Exp   | Obs/Exp   | Obs/Exp   | Obs/Exp   |
|                | Compulsory| Upper     | Post-      | Compulsory| Upper     | Post-      | Compulsory| Upper     | Post-      | Compulsory| Upper     | Post-      |
| January        | 94 92 90 96 95 98 99 98 98 98 97 94 |            |           |            |            |           |            |            |            |            |            |           |
| February       | 100 100 99 104 104 106 104 106 109 102 102 102 |            |           |            |            |           |            |            |            |            |            |           |
| Mars           | 110 112 113 113 113 115 107 112 115 101 104 105 |            |           |            |            |           |            |            |            |            |            |           |
| April          | 113 114 119 116 118 117 109 115 118 103 107 109 |            |           |            |            |           |            |            |            |            |            |           |
| May            | 109 111 114 109 110 108 104 107 109 101 105 106 |            |           |            |            |           |            |            |            |            |            |           |
| June           | 104 104 102 102 102 98 103 105 105 102 106 106 |            |           |            |            |           |            |            |            |            |            |           |
| July           | 100 98 95 98 97 95 102 103 102 105 107 107 |            |           |            |            |           |            |            |            |            |            |           |
| August         | 96 94 91 94 94 94 100 99 99 99 102 103 |            |           |            |            |           |            |            |            |            |            |           |
| September      | 101 100 101 99 99 100 101 99 98 102 101 102 |            |           |            |            |           |            |            |            |            |            |           |
| October        | 93 94 95 93 94 94 93 89 88 99 96 95 |            |           |            |            |           |            |            |            |            |            |           |
| November       | 90 90 89 89 88 88 90 84 80 94 89 87 |            |           |            |            |           |            |            |            |            |            |           |
| December       | 92 92 92 87 87 86 89 83 79 92 83 81 |            |           |            |            |           |            |            |            |            |            |           |

Adjusted for each month’s number of days and mother’s age, country of birth, and parity.

Figure 2a. Seasonal variation in births by education (1940-1959)

Figure 2b. Seasonal variation in births by education (1960-1979)

Figure 2c. Seasonal variation in births by education (1980-1999)

Figure 2d. Seasonal variation in births by education (2000-2012)
Table III. Observed/expected probabilities of births by month, years, and country of birth.

| Month of birth | 1940-1959 | 1960-1979 | 1980-1999 | 2000-2012 |
|----------------|-----------|-----------|-----------|-----------|
|                | Obs/Exp   | Obs/Exp   | Obs/Exp   | Obs/Exp   |
| Nordic Country | Other     | Nordic Country | Other     | Nordic Country | Other     | Nordic Country | Other     |
| January        | 93        | 96        | 96        | 93        | 98        | 96        | 96        | 95        |
| February       | 100       | 96        | 104       | 99        | 107       | 101       | 103       | 98        |
| Mars           | 110       | 107       | 113       | 103       | 113       | 101       | 106       | 98        |
| April          | 113       | 109       | 117       | 109       | 115       | 104       | 109       | 102       |
| May            | 110       | 105       | 109       | 108       | 107       | 105       | 106       | 103       |
| June           | 104       | 104       | 101       | 107       | 105       | 105       | 106       | 105       |
| July           | 100       | 97        | 97        | 101       | 102       | 104       | 107       | 105       |
| August         | 95        | 96        | 94        | 97        | 99        | 101       | 104       | 103       |
| September      | 100       | 103       | 99        | 100       | 99        | 101       | 102       | 102       |
| October        | 93        | 95        | 93        | 96        | 89        | 97        | 95        | 100       |
| November       | 90        | 97        | 89        | 93        | 84        | 92        | 87        | 95        |
| December       | 92        | 96        | 87        | 94        | 82        | 94        | 81        | 94        |

Adjusted for each month’s number of days and mother’s age, education, and parity.

Figure 3a. Seasonal variation in births by country of birth (1940-1959)

Figure 3b. Seasonal variation in births by country of birth (1960-1979)

Figure 3c. Seasonal variation in births by country of birth (1980-1999)

Figure 3d. Seasonal variation in births by country of birth (2000-2012)
Table IV. Observed/expected probabilities of births by month, years, and parity.

| Month of birth | 1940-1959 | 1960-1979 | 1980-1999 | 2000-2012 |
|----------------|-----------|-----------|-----------|-----------|
|                | Obs/Exp   | Obs/Exp   | Obs/Exp   | Obs/Exp   |
| January        | 1st 93    | 2nd 93    | 3rd+ 97   | 1st 95    | 2nd 96    | 3rd+ 96   |
|                |           |           |           |           |           |           |
| February       | 1st 100   | 2nd 100   | 3rd+ 102  | 1st 105   | 2nd 103   | 3rd+ 109  |
|                |           |           |           |           |           |           |
| Mars           | 1st 112   | 2nd 110   | 3rd+ 110  | 1st 116   | 2nd 110   | 3rd+ 115  |
| April          | 1st 115   | 2nd 114   | 3rd+ 113  | 1st 121   | 2nd 109   | 3rd+ 118  |
| May            | 1st 112   | 2nd 110   | 3rd+ 112  | 1st 112   | 2nd 103   | 3rd+ 110  |
| June           | 1st 105   | 2nd 104   | 3rd+ 101  | 1st 103   | 2nd 106   | 3rd+ 105  |
| July           | 1st 101   | 2nd 99    | 3rd+ 99   | 1st 98    | 2nd 103   | 3rd+ 102  |
| August         | 1st 95    | 2nd 94    | 3rd+ 97   | 1st 92    | 2nd 95    | 3rd+ 98   |
| September      | 1st 100   | 2nd 106   | 3rd+ 102  | 1st 97    | 2nd 101   | 3rd+ 98   |
| October        | 1st 92    | 2nd 93    | 3rd+ 96   | 1st 91    | 2nd 94    | 3rd+ 93   |
| November       | 1st 87    | 2nd 91    | 3rd+ 90   | 1st 87    | 2nd 92    | 3rd+ 89   |
| December       | 1st 89    | 2nd 92    | 3rd+ 89   | 1st 84    | 2nd 94    | 3rd+ 79   |

Adjusted for each month’s number of days and mother’s age, education, and country of birth.

Figure 4a. Seasonal variation in births by parity (1940-1959)

Figure 4b. Seasonal variation in births by parity (1960-1979)

Figure 4c. Seasonal variation in births by parity (1980-1999)

Figure 4d. Seasonal variation in births by parity (2000-2012)
Table V. Observed/expected probabilities of higher order birth by month, years, and repartnering.

| Month of birth | 1940-1959 | 1960-1979 | 1980-1999 | 2000-2012 |
|----------------|-----------|-----------|-----------|-----------|
|                | Obs/Exp   | Obs/Exp   | Obs/Exp   | Obs/Exp   |
|                | Same father | New father | Same father | New father | Same father | New father | Same father | New father | Same father | New father |
| January        | 93        | 92        | 96        | 97        | 98        | 100       | 95        | 99         |           |           |
| February       | 100       | 95        | 106       | 99        | 108       | 105       | 103       | 103        |           |           |
| Mars           | 110       | 105       | 117       | 106       | 115       | 107       | 107       | 102        |           |           |
| April          | 113       | 108       | 122       | 106       | 118       | 108       | 112       | 103        |           |           |
| May            | 110       | 103       | 112       | 102       | 109       | 105       | 109       | 102        |           |           |
| June           | 104       | 101       | 103       | 104       | 106       | 106       | 107       | 104        |           |           |
| July           | 100       | 102       | 96        | 99        | 101       | 105       | 107       | 110        |           |           |
| August         | 95        | 95        | 91        | 99        | 98        | 101       | 103       | 104        |           |           |
| September      | 99        | 105       | 96        | 104       | 98        | 99        | 101       | 101        |           |           |
| October        | 93        | 97        | 91        | 96        | 88        | 89        | 94        | 96         |           |           |
| November       | 91        | 96        | 87        | 95        | 81        | 89        | 84        | 90         |           |           |
| December       | 92        | 99        | 84        | 93        | 79        | 87        | 78        | 86         |           |           |

Adjusted for each month’s number of days and mother’s age, education, country of birth, and parity (higher order birth).

![Figure 5a](image-url) Seasonal variation in higher order birth by re-partnering (1940-1959)

![Figure 5b](image-url) Seasonal variation in higher order birth by re-partnering (1960-1979)

![Figure 5c](image-url) Seasonal variation in higher order birth by re-partnering (1980-1999)

![Figure 5d](image-url) Seasonal variation in higher order birth by re-partnering (2000-2012)
Summary and Discussion

Our study showed that the seasonal variation in childbearing in Sweden has declined during the first decade of the twenty-first century, and also that it has changed in its sociodemographic structure during the course of the twentieth century. During the six decades of the twentieth century we study, Swedish birth rates showed the typical seasonal variation with high numbers of births during the spring and low numbers of births during the last quarter of the year. However, during the new century, the seasonal variation clearly declined to a situation where there was only minor variation in birth rates between February to September. The pattern of low birth rates at the end of the year still remained and even gained in magnitude. Additionally, the previously characteristic Christmas peak in September has vanished over the last three decades.

The role of mother's educational attainment begun to matter during the 1980s, when the seasonal variation among mothers with only compulsory education started to decrease drastically. In the twenty-first century, the effect of the mother’s education on the birth month primarily manifests itself as a decline in the birth rate during the last quarter of the year among mothers with high or medium-level education. In the early decades, the difference in the seasonal variation in births between Nordic-born mothers and mothers from other countries was very minor. During the last four decades of study, mothers from non-Nordic countries showed almost no seasonal variation in childbearing. From the 1960s onwards, second-time mothers exhibit the most pronounced seasonal variation. In the twenty-first century, second-order births spike in spring and decline sharply at the end of the year. The seasonal variation for first-time mothers have become less pronounced over time. Throughout the study period, mothers who re-partnered between subsequent births displayed less seasonal variation than mothers who resumed childbearing with the same partner. The differences between re-partnered and other mothers were strongest during the 1960s to 1970s.
All meaningful differences reported in the results section are statistically significant. Using data with approximately 180,000 births in each month, any confidence intervals in outcomes become very narrow. Dividing the calendar years in groups other than those presented here does not considerably affect the results. When single decades are used instead of twenty-year cohorts, some patterns are amplified, but overall, the results remain the same.

Much previous research on the causes of human birth seasonality has focused on the physical environment, such as temperatures and photoperiods (Jongbloet, 1983; Kallan and Udry, 1989; Roenneberg and Aschoff, 1990a; 1990b Lam and Miron, 1991; Lam and Miron, 1996; Smits et al., 1998). It has been argued that both social and biological factors account for seasonal variation in births, but that the latter matter the most (Roenneberg and Aschoff, 1990a). These factors may matter more in contexts located at extreme latitudes, such as the Nordic countries, with their much larger seasonal variation in temperatures and day-light exposure. However, in keeping with the findings of the present study, it is likely that the effect of biological factors has become weaker in contemporary advanced societies where childbearing is much more strongly determined by factors related to conscious planning and individual choice (Goldin and Katz, 2000).

Childbearing decisions today take place in a very different context than those of the agricultural and industrial societies of the past, where factors related to harvests and vacation times (James, 1971; Basso et al., 1995) had huge bearing. During the last half a century the labour market underwent two fundamental changes; women’s increased activity (Hoem, 2000; Stanfors and Goldscheider, 2017) and the transition from an industry- to a service-dominated occupational structure (Esping-Andersen, 1993). At the same time, family patterns in the Nordic countries have changed so that men have become increasingly engaged in issues related to childrearing (Goldscheider et al., 2015). Not only has women’s participation in the labour force increased (in Sweden; from 50% in 1960 to 80% in 1990), but their
occupational aspirations have increased as well. Women have come to dominate many fields of higher education and the gender wage-gap has decreased. In dual-earner dual-carer couples where both partners’ career developments might be affected by childbearing decisions it may be less optimal to follow traditional seasonality patterns and more rational instead to plan childbearing so that it suits both partners’ occupational careers. Another factor to consider is that Swedish fathers’ uptake of parental leave has increased steadily over time so that they now use about one quarter of all parental leave days (Swedish Social Insurance Agency, 2017). Couples that share their parental leave more equally may have incentives to plan their childbearing so that it suits both parents’ occupational trajectories. With about one and half year of parental leave to share it may in some cases be perceived fair to become a parent during a summer month, with the possibility to shift the leave from one parent to the other during the following summer.

Evidently, the transition to a services-dominated society has created a much more diverse labour force in terms of work schedules, working hours, and employment types (Kalleberg, 2000). In a society with less standardized employment structures, behavioural factors related to the frequency of intercourse and standardized vacation schedules may become less important for seasonal variations in childbearing. These changes have occurred in tandem with the observed decline in elevated birth rates during the spring season.

Still, some of the late 20th century patterns in seasonality remain intact. These are also the ones that appear most related to the conscious planning of the timing of births. Our main finding is that of distinct differences between the number of births that happen at the end of a calendar year and those that take place in the first few months of a year. The increasingly strong pattern of depressed birth rates in November and December is likely explained by the December-January cut-off threshold for Swedish pupils’ school entry and their parents increasing awareness of the negative effects on school outcomes for children.
who are juniors in the school-entry cohort they belong to (Bedard and Dhuey, 2006). In other countries, other cut-off rules may produce other patterns of seasonality. Well-educated parents tend to be more likely to invest in their children's education (Useem, 1992) and thus be more concerned over matters of this nature. The results show that mothers with higher education are significantly more likely to avoid births late in the year.

Previous research has shown that high educated Japanese parents make an effort to have their children born on the right side of the cut-off date for school entry in order to give their children an advantage within the education system. Based on data on 50 million births during 1974–2010 Shigeoka (2013) shows that more than 1,800 births per year are delayed about week to occur after the cut-off date, by means of postponed Caesarean sections, mostly by highly educated mothers.

Our study shows that patterns of seasonality varies by parents socio-demographic characteristics in ways that are related to their incentives for and possibilities to plan for the timing of their births. For example, women with previous births are equipped with a better understanding of their fecundity, and therefore better able to plan their next birth so that it does not occur at the end of a year. Also mothers with no re-partnering interruptions in their childbearing career should be better able to plan the timing of any next birth.

Our study supports the notion that cultural norms regarding childbearing decisions are relatively weak in contemporary societies, and that increased individual autonomy and self-realisation have contributed to more diversity in childbearing behaviour (Surkyn and Lesthaeghe, 2004; Billari et al., 2010). Sweden was among the first countries to enter what is often termed the second demographic transition, with declining marriage rates, increased childbearing outside marriage, increases in divorce and cohabitation, as well as a value shift towards more individualistic and expressive values (Lesthaeghe 2010; Sobotka and Toulemon 2008; van de Kaa 2002). In a society with below-replacement and highly
controlled fertility due to efficient contraception, active choices and behaviours associated with individual sociodemographic characteristics may matter more than the physiological ability to reproduce (Bobak and Gjonca, 2001). Increased individual autonomy and self-realisation might have overridden the role of factors that influence the physiological ability to reproduce and cultural behaviours that affect the likelihood of sexual intercourse.

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