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TITLE	Seasonality of Birth Weight in Singleton Full-term Births in Finland
YEAR	2024
DOI	https://doi.org/10.23979/fypr.136379
VERSION	Publisher's PDF
CITATION	Orderud, H., Eskelinen, N., & Lindberg, M. (2024). Seasonality of Birth Weight in Singleton Full-term Births in Finland. Finnish Yearbook of Population Research, 57, 21–46. https://doi.org/10.23979/fypr.136379
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Seasonality of Birth Weight in Singleton Full-term Births in Finland

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Abstract

Seasonal birth weight has been identified across different climate zones. Finland has wide seasonal and regional variation in climate within the country. We explore the potential seasonality of birth weight in singleton full-term births in Finland, and its variations across time and within the country. We apply descriptive time-series graphs, linear regression across regions, and linear regression with mother fixed effects using Finnish register data consisting of more than 1,800,000 infants born from 1987 to 2021. The descriptive findings indicate a decline in birth weight from 1987 to 2021. A monthly seasonal trend with peaks in spring and autumn and troughs in summer and winter is observed. The pattern gets less distinct with time and shows within-country variations. The seasonal pattern is also present when applying mother fixed effects. We suggest that the seasonal variation is more related to variations in climate than stable characteristics at the family level.

Keywords: birth weight, seasonality, climate, Finland

Introduction

Birth weight is an important indicator of both early and later life health (Black et al., 2007; Torche & Conley, 2016). Adverse adult health and several socioeconomic outcomes in later life have been associated with lower birth weight (Almond et al., 2018; Barker, 2004; Black et al., 2007; Calkins & Devaskar, 2011). Seasonality in birth weight refers to the phenomenon where birth weights of infants vary according to the season in which they are born. The existence of seasonality has been reported across the world in several studies and researchers have attempted to identify the underlying factors (Beltran et al., 2013; Chodick et al., 2007). The seasonality of birth weight varies with geographical locations and populations, and observations often show a pattern of lower birth weight for children born during the colder months, a peak in birth weight during spring, a drop during the summer months, and a rise again in autumn (Beltran et al., 2013). It has been noted that the seasonal pattern of birth weight may change over time (Jensen et al., 2015) and may vary across regions within countries (Torche & Corvalan, 2010). A range of reasons for the seasonal variation have been suggested by previous research, such as socioeconomic characteristics, seasonal patterns in pregnancy weight gain, infectious diseases, food production, air pollution, extreme temperatures, precipitation, and hours of sunlight (Becker, 1991; Chodick et al., 2009; Currie & Schwandt, 2013; Fong et al., 2019; Strand et al., 2011).

The aim of this paper is to explore whether there is a seasonal pattern in birth weight in singleton full-term births in Finland and analyse the potential fluctuation. Furthermore, we study whether a possible seasonal pattern varies across time and within the country. Finland provides an interesting context to study seasonal patterns in birth weight, since it is located in the northern part of Europe with parts of the population living above the arctic circle with both polar nights and midnight sun. Furthermore, the Finnish climate shows great variation in temperature in the northern and the eastern central part of Finland, while the western central and the southern part of Finland are located closer to the coast and have less variation in temperature. An important contribution of this study is therefore to identify whether a seasonal pattern in birth weight in full-term births exists in Finland and whether there are differences across time and geographical regions, which will contribute to better understanding of the underlying factors of seasonality in birth weight. A study by Rantakallio from 1971 described a pattern of slightly higher birth weights in spring and autumn compared to other seasons (Rantakallio, 1971). However, Rantakallio's study was situated in the Northern part of Finland focusing on Finns residing in this region. To the best of our knowledge, there are no other studies that have investigated the seasonality in birth weight in Finland. Hence, whether the seasonality of birth weight has remained the same in Finland after 1971 and whether there is variation in seasonality within the country is not known.

By studying the Finnish context, we contribute to a better understanding of the seasonal pattern across time and within a country located in Northern Europe using a large nationally representative sample with well-recorded information on birth weight and a long follow-up period. Further, by including a mother fixed effects approach in our analysis, we add to previous research where the aim has been to disentangle and explore the reasons behind the seasonal pattern. Knowing more about how birth weight varies by season is especially important due to a changing climate and predictions of more extreme weather events and extreme temperatures in the future.

Background

A seasonal pattern in birth weight has been observed across different climatic zones (Becker, 1991; Chodick et al., 2009), and within country variations and changes in seasonal pattern across time have been seen (Jensen et al., 2015; Torche & Corvalan, 2010). Research on seasonality of birth weight in the Northern hemisphere is scarce, but some studies from Northern Europe have indicated that the lowest birth weights occur during winter (Chodick et al., 2009). We begin by reviewing literature on changes in birth weight across time before investigating literature on the factors contributing to seasonality in birth weight.

Mean annual birth weights are likely to change over time, and a decrease has been observed in some studies from the United States (Donahue et al., 2010; Morisaki et al., 2013; Oken, 2013). Oken (2013) suggests that a reduction in birth weight could possibly be explained by decreases in gestation length mainly caused by obstetric interventions such as induced labour and elective caesarean delivery, though Donahue et al. (2010) argue that such changes in practice cannot explain the decrease in birth weight, and Morisaki et al. (2013) argue that the birth weight decreased even in populations without any change in gestational length. Changes in assessment of gestational age across time may be part of the explanation as well (Donahue et al., 2010). Also in South Korea, a decrease in mean birth weight of 3 grams per year among singleton births has been observed between 2000 and 2020 (Hur, 2023). The same study showed that gestational age decreased during the same period by around 5.6 days. In France, a mixed picture has been observed with an increasing trend in birth weight between 1972 and 1995, and a decreasing trend between 1995 and 2003 (Diouf et al., 2011).

On the other hand, an increase in birth weight across time has been observed in several other countries. In Denmark, mean birth weight increased by 5 grams per year on average between 1973 to 2003, which is 2 grams higher than what was reported in Norway and Sweden (Schack-Nielsen et al., 2006). The increase was still present after controlling for the increase in maternal age and decrease in smoking. A recent study from the Faroe Islands showed an increase of 93 grams in birth weight of singleton Faroese infants born between 2010–2019, although the same increase could not be found in other Nordic countries (Olsen et al., 2023). The authors suggest that this could possibly be explained by a larger proportion of infants born in gestational week 41 or later compared to the other Nordic countries, which possibly could relate to differences in the practice of labour induction (42 weeks and 0 days in Faroe Islands and 41weeks and 5 days in other Nordic countries). As a comparision, Finland has the lowest proportion of post-term births among the Nordic countries at 2.0 per cent (Heino & Gissler, 2022). In the UK an increase in birth weight was also observed between 1986 and 2012, but whether this increase can be explained by an increase in fetal growth or length of gestation is not known (Ghosh et al., 2018). Changes in mean birth weight over time can also be related to an increased pre-pregnancy body mass index (BMI) among expectant mothers and the rising prevalence of gestational diabetes mellitus (GDM), which are associated with an elevated risk of perinatal complications. Screening practices for GDM have changed over time, also affecting pregnancy outcomes and perinatal statistics. In the Finnish context, transition from risk-factor-based screening to comprehensive screening for GDM resulted in a reduction in birth weight (Koivunen et al., 2017; Ellenberg et al., 2017).

Despite research having identified seasonal patterns in birth weight, the reasons behind such patterns are not yet fully explored but are expected to vary by climatic regions and socioeconomic conditions (Becker, 1991; Chodick et al., 2009; Strand et al., 2011). One explanation for the seasonal pattern in birth weight is socioeconomic characteristics, as women with certain socioeconomic characteristics may give birth at specific times of the year. For instance, mothers with low socioeconomic status tend to give birth during seasons associated with poorer birth outcomes on average. However, such characteristics only account for a small part of the seasonal variation in birth weight (Currie & Schwandt, 2013; Torche & Corvalan, 2010). Another possible explanation for the increased likelihood of lower birth weight at certain times of the year is infectious diseases. Examples include malaria and influenza, which both have seasonal patterns and potentially could contribute to confounding or mediating the association between seasonality and birth weight (Beltran et al., 2013; Grace et al., 2021). For example, Dorélien (2019) found that third-trimester exposure to seasonal influenza peaks in the United States is associated with lower birth weights and increased risk of being born with low birth weight (< 2,500 grams). Additionally, in some countries food production is likely to impact maternal nutrition (Chodick et al., 2009; Grace et al., 2021). Seasonality in food production could therefore contribute to the seasonality in birth weight. Further, physical labour linked to agriculture and food production might also impact the health of the pregnant mother and consequently impact birth weight (Chodick et al., 2009).

Furthermore, climate- and weather-related explanations of seasonality in birth weight have been researched. A range of studies have explored the impact of ambient temperatures on birth weight (Chodick et al., 2007). Extreme hot temperatures have been associated with increased chances of being born with lower birth weight, though the findings are not consistent across countries (Chersich et al., 2020; Kuehn & McCormick, 2017). Cold temperatures have also been studied, although less so and with inconsistent results (Hajdu & Hajdu, 2021; Liu et al., 2022; Poursafa et al., 2015). Ha et al. (2017) studied the exposure to site-specific temperature extremes and found that exposure to hot or cold temperature extremes in mid and late pregnancy were linked with full-term low birth weight risk. They suggested that one plausible mechanism driving the effect is that exposure to extreme temperatures affect uterine blood flow and placental exchange between the fetal and maternal systems necessary for the fetal growth. Another potential explanation, especially for countries in Northern Europe, are seasonal variations in vitamin D due to sunshine exposure. However, a study from Denmark (Jensen et al., 2015) could not explain the seasonal variation in birth weight by exposure to sunshine, while a study from New Zealand found an association between exposure to sunshine and birth weight depending on which trimester had peak exposure (Tustin et al., 2004). Also, precipitation has been shown to increase birth weight in countries and societies that depend on agricultural production, while extreme hot temperatures decreases birth weight in such contexts (Bakhtsiyarava et al., 2018).

Explanations for seasonality in birth weight have been directed more towards temperatures and exposure to sunlight in high-income countries and towards agriculture activities, food production, and physical labour in low-income countries closer to equator. Thus, seasonal variation in birth weight is likely to be impacted by mechanisms both between and within countries dependent on the climatic zone and socioeconomic context.

Data and methods

We analyse seasonality in birth weight for singleton full-term infants born from 1987 to 2021 using high-quality register data obtained from the Finnish Institute for Health and Welfare. The data are based on the Finnish Medical Birth Register (FMBR). The register contains information on infants born in Finland with a birth weight of at least 500 grams or with a gestational age of at least 22 weeks, as well as a wide range of medical and health-related data on mothers.[1] For our analysis we include only singleton full-term infants born in gestational week 37 or later with available information on birth weight. Data on birth outcomes are collected at the time of birth. For the socioeconomic variables, data from FMBR are linked with other population registers derived from Statistics Finland. We acknowledge that not separating between infants born at different gestational weeks could affect our results, since a decrease of only a few days of gestational age can influence birth weight (Diouf et al., 2011). To explore potential geographical differences in the seasonal pattern of birth weight we use the mother's place of residence, i.e., the municipality registered upon admission at the maternity hospital. In general, it is not common that pregnant women are registered in one municipality but live in a different one, but it cannot be ruled out based on the available information. Mothers with missing information on municipality (253 children) or who were living abroad (4,300 children) at the time of admission to the maternity hospital were excluded from the analysis. Additionally, we excluded mothers with uncertain information on which municipality they were living in at the time of the birth due to changes in municipality structure across time (389 children). We analysed a total of 1,866,980 singleton term infants born from 1987 to 2021, out of which 364,644 were only children.

Finland is a North European country with great differences in temperature and hours of sunlight. In our analysis, we wanted to explore geographical regions with clear differences in climate and we therefore divided Finland into four regions to observe potential differences in seasonal birth weight between the north, south, eastern central, and western

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[1] Description of data from the Medical Birth Register: https://thl.fi/en/web/thlfi-en/statistics-and-data/data-and-services/quality-and-statistical-principles/quality-descriptions/parturients-delivers-and-newborns

central part of the country (Appendix, Table 1). Northern Finland is north of approximately 65º north (latitude), Eastern Central is the area inland without any coastline, while Western Central is along the coast, and the Southern region is south of approximately 61º north (latitude) along the southern coast (Figure 1 and Appendix, Table 2). The Northern and Eastern Central both have greater temperature variations than the Western Central and Southern regions. Additionally, the Northern region also has great variation in hours of sunlight during the year with polar nights and midnight sun.

First, we explore the seasonality in birth weight by illustrating time-series graphs for birth weight. We summarise the birth weight means by month–year to observe the seasonality over time and also present the monthly mean for the entire observation period from 1987 to 2021. A smoothed line with the Stata command *lowess* and a bandwidth equal to 30% of the data were applied to the time-series graph. A table with the number of singleton full-term births and histograms of the distribution of birth weights per month are included in the Appendix (Appendix, Table 3 and Figure 1). Further we explore the monthly means for three time periods that were identified based on our first analysis of the entire period, which are from January 1987 to December 1996 (1987m1–1996m12), January 1997 to December 2009 (1997m1–2009m12), and January 2010 to December 2021 (January2010m1–2021m12) (see Results and Figure 2 for more details). We also illustrate the mean monthly variation in birth weight across the four regions.

Figure 1. *Map of Finland showing the four regions created for our analysis. The map is generated with QGIS and administrative maps.*[2]

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[2] Administrative maps from GADM: https://gadm.org/

Second, we apply linear regression with the dependent variable birth weight and months as independent variables to explore seasonality in birth weight. The months were created as dummies for each month except December, which was left as a reference group. Troughs are expected in winter, so we considered December to be a good reference month to the other months. We control for regions, the three distinct time periods previously mentioned, maternal age, birth order, and maternal education. Then we follow up with region-specific regression models to explore the possible differences across geographical regions, also controlling for maternal age, birth order, maternal education, and time periods. Clustered robust standard errors are included at the municipality level, since there may be potential variations between municipalities in the seasonal impact on birth weight.

Finally, we apply a mother fixed effects model, controlling for maternal age, sex, and birth order that varies between siblings. The key caveat of the mother fixed effects models is that these models utilise the variation between children born by the same mother. Models, therefore, implicitly control for any unmeasured factors that are shared with siblings and constant at the family level, such as socioeconomic background, pre-childbearing health behaviours, and some maternal health and genetic factors (Aradhya et al., 2023). This approach allows us to adjust several potential confounders without requiring them to be measured or known.

Statistical analyses are done with Stata 16.1.

Sensitivity analysis

Two sensitivity analysis are applied. First, we apply the mother fixed effects analysis without induced births, since induced births could be related to birth weight. The variable induced births is described as artifically starting labour in a situation where spontanous uterine contractions have not begun. There were no restrictions regarding type of delivery. Secondly, we explore days of gestational age from week 37 until birth as a dependent variable. Fetuses tend to gain weight quickly at the end of the pregnancy, and gestational age after week 37 could therefore also have a seasonal pattern similar to what has been observed for birth weights.

Results

We begin our analysis by investigating the trend across time and whether there are variations in the seasonal pattern across time and across geographical regions in Finland. First, we explore the overall trend in mean monthly birth weight with a time series graph from 1987 to 2021 for all of Finland. During the period studied we observe a downward trend from approximately 3625 grams in 1987 to approximately 3575 grams in 2021 (Figure 2).

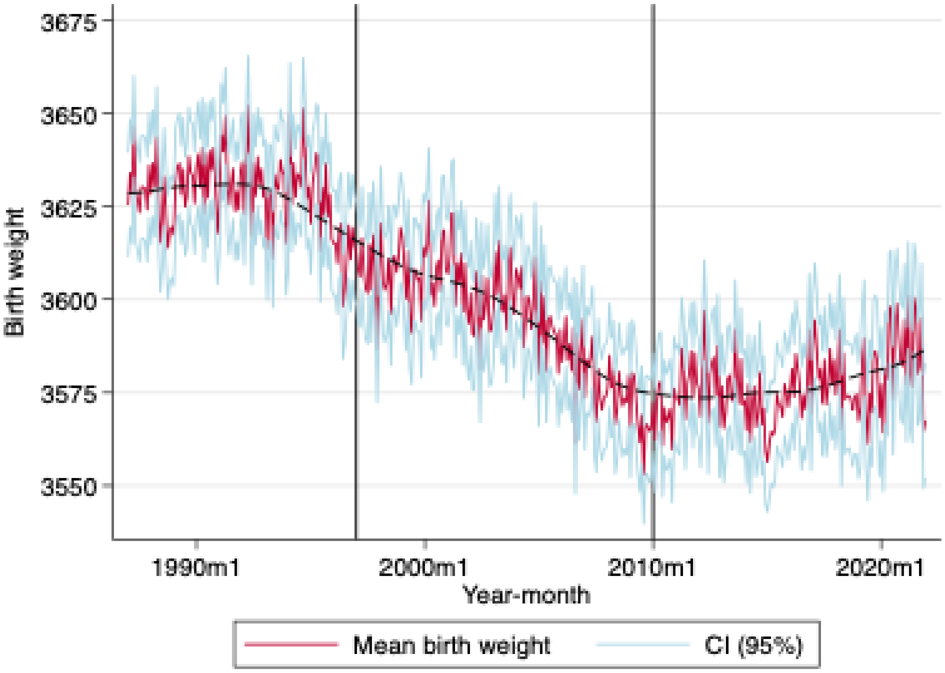

Figure 2. *Mean monthly birth weight and confidence intervals for singleton full-term births in all of Finland across the entire observation period with a lowess smoothed line. The smoothing was performed using a bandwidth equal to 30% of the data.*

As noted above, we identify three time periods for birth weights by investigating the mean monthly birth weights and the smoothed line in Figure 2. The mean monthly birth weight has a slightly downward trend between 1987 to 1996 with birth weights around 3600–3650 grams. Between 1997 and 2009 there is a clear downward trend with birth weights between around 3575–3625 grams. The last time period from 2010 to 2021 shows a slightly upward trend with birth weights around 3575–3585 grams.

Next, we turn our focus to seasonality by looking at the overall mean birth weight across months. Figure 3 shows that there is a seasonal pattern in birth weight with peaks in spring (April) and autumn (September) and troughs in summer (June) and winter (December).

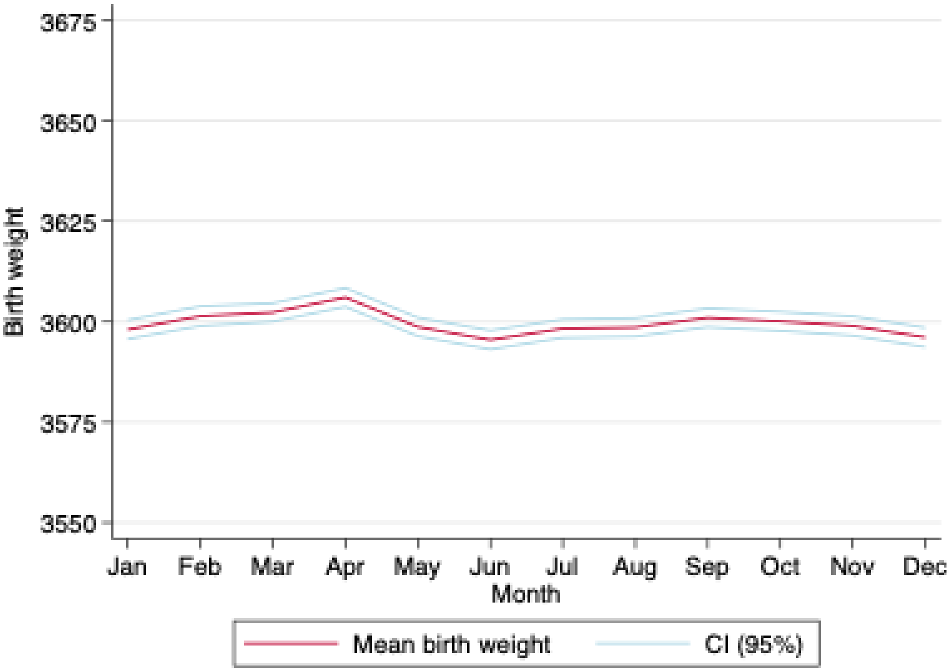

Figure 3. *Mean birth weight and confidence intervals for singleton full-term births in all of Finland across months.*

Further, we explore whether there are variations in the seasonal pattern of birth weight across time. The time periods identified in Figure 2 are used to study if the seasonal pattern varies across these periods (Figure 4). All three time periods have similarities in their monthly pattern in birth weight but are less distinct with time. The first period (1987–1996) has a clear and distinct spring peak in April, while for the other two time periods the spring peaks either start earlier (1997–2009) and/or stay higher for about three months (1997–2009 and 2010–2021). The summer trough is more distinct for the first two time periods (1987–1996 and 1997–2009) and less pronounced for the most recent time period (2010–2021), while the winter trough occurs mainly in the first two periods (1987–1996 and 1997–2009). Seasonality in monthly birth weight shows a clearer pattern for the period 1987–1996 and seems to diminish gradually over time with less variations across months.

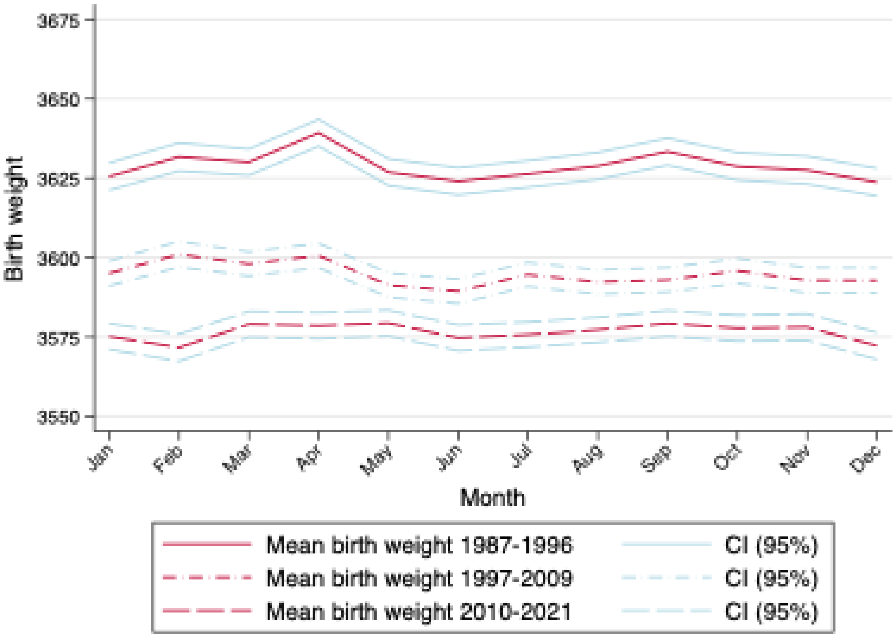

Figure 4. *Mean birth weight and confidence intervals for singleton full-term births in all of Finland across months for specific time periods.*

We also explore the regional mean monthly birth weight and observe that all regions except for the Southern region have a seasonal pattern as presented earlier, with peaks in spring and autumn and troughs in summer and winter (Figure 5). This pattern, however, is more pronounced for the spring peak and summer trough in Northern, Eastern Central and Western Central regions, while the autumn peak is more noticeable for the Northern and Western Central regions. The lowest mean monthly birth weights are in the Northern region (below 3600 grams) and the highest mean monthly birth weights are in the Western Central (just below 3650 grams).

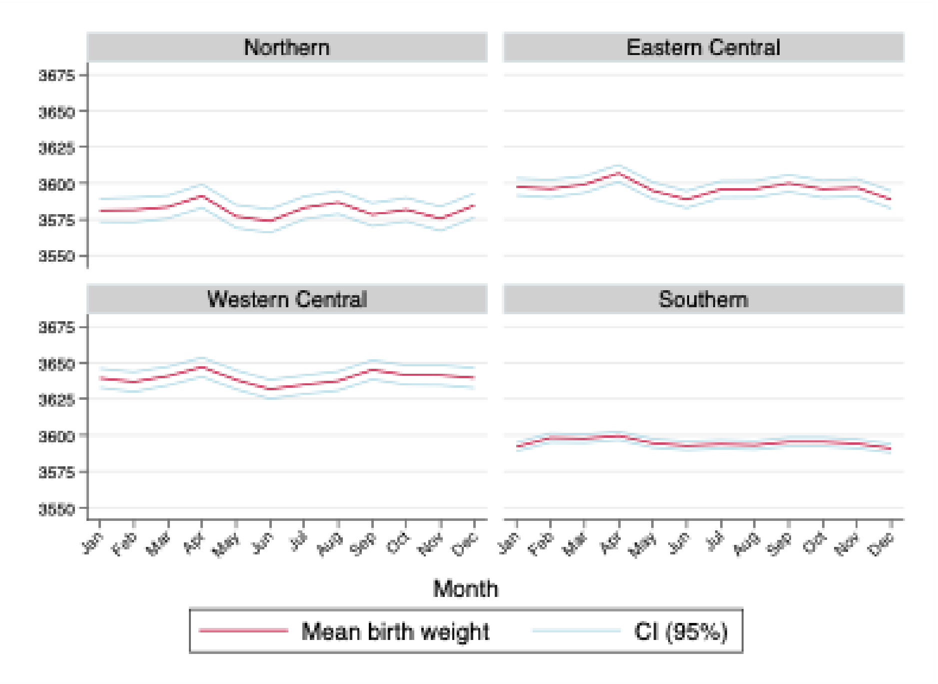

Figure 5. *Mean birth weight and confidence intervals for singleton full-time births for the four regions in Finland across months.*

Second, we apply linear regression to explore seasonal patterns in birth weight across months for all of Finland and separately for the four regions. The results for all of Finland presented in Table 1 show peaks in birth weight for spring (February, March, and April) and autumn (September and October) with December as reference month. The spring peak is 4.323 to 7.774 grams higher than the mean monthly birth weight in December, while the autumn peak is 3.963 to 4.393 grams higher than the mean monthly birth weight in December.

The regional regression models (Table 2) show a summer trough in the Northern region, with respectively 11.942 grams lower mean birth weights in June than in December. The Eastern Central region shows clear peaks in spring (April) and autumn (September and October), with 16.324 grams higher birth weight in spring and 7.795 to 10.290 higher birth weight in autumn. The spring peak appears to start early, with higher birth weights also for January and February (8.102 and 7.793 higher birth weight than in December). For the Southern region we also observe an early spring peak lasting from February to April, with 5.227 grams to 6.907 grams higher birth weight than December, and an autumn peak in October with 4.252 grams higher birth weight than December.

Table 1. *Results for linear regression of birth weight on monthly dummies with December as the comparison group for all of Finland. Clustered robust standard errors at municipality level.*

	All Finland		
Variables	**Coeff.**	**(SE)**	**P-Val.**
Jan	2.234	(1.936)	0.249
Feb	4.830	(1.632)	0.003
Mar	4.323	(1.700)	0.011
Apr	7.774	(1.797)	0.000
May	1.451	(1.653)	0.381
Jun	-1.502	(1.897)	0.429
Jul	2.231	(1.741)	0.201
Aug	2.607	(1.669)	0.119
Sep	4.393	(1.849)	0.018
Oct	3.963	(1.506)	0.009
Nov	2.858	(1.851)	0.124
Dec	Ref.	(-)	(-)
Age	-1.994	(0.136)	0.000
Age squared	-0.125	(0.010)	0.000
Birth order (first)	Ref.	(-)	(-)
Second	145.606	0.912	0.000
Third	184.702	2.156	0.000
Fourth or higher	209.677	2.898	0.000
Education (primary)	Ref.	(-)	(-)
Secondary	70.978	(3.318)	0.000
Tertiary	85.071	(2.408)	0.000
Period (1987–1996)	Ref.	(-)	(-)
1997–2009	-34.899	(2.813)	0.000
2010–2021	-52.303	(1.983)	0.000
Region (Northern)	Ref.	(-)	(-)
Eastern Central	16.939	(8.476)	0.047
Western Central	48.550	(9.034)	0.000
Southern	30.637	(8.303)	0.000
Cons	3493.964		
Observations	1,866,980		
Prob>F	0.0000		
R-squared	0.0341		

Table 2. *Results of linear regression of birth weight on monthly dummies with December as the comparison group by region. Clustered robust standard errors at municipality level.*

	Northern			**Eastern Central**			**Western Central**			**Southern**		
Variables	**Coeff.**	**(SE)**	**P-val.**	**Coeff.**	**(SE)**	**P-val.**	**Coeff.**	**(SE)**	**P-val.**	**Coeff.**	**(SE)**	**P-val.**
Jan	-3.810	(6.261)	0.548	8.102	(3.740)	0.034	-0.417	(4.688)	0.929	2.124	(2.634)	0.421
Feb	-4.260	(7.520)	0.576	7.793	(3.257)	0.019	-2.914	(4.849)	0.550	6.907	(2.057)	0.001
Mar	-3.182	(4.650)	0.500	8.376	(4.270)	0.054	-0.466	(4.417)	0.916	5.227	(2.113)	0.015
Apr	5.182	(6.528)	0.435	16.324	(3.941)	0.000	5.137	(3.958)	0.199	6.482	(2.311)	0.006
May	-9.558	(5.590)	0.100	4.962	(3.680)	0.182	-1.644	(5.019)	0.744	2.697	(2.012)	0.182
Jun	-11.942	(4.557)	0.015	-1.087	(3.943)	0.783	-7.244	(4.603)	0.120	0.990	(2.568)	0.701
Jul	-2.250	(5.379)	0.679	6.836	(4.333)	0.119	-4.134	(4.435)	0.355	2.978	(2.280)	0.194
Aug	1.167	(5.231)	0.825	7.050	(4.503)	0.122	-1.754	(4.556)	0.702	2.580	(2.046)	0.209
Sep	-5.883	(3.842)	0.138	10.290	(4.637)	0.030	4.487	(3.930)	0.258	4.162	(2.452)	0.092
Oct	-2.476	(4.844)	0.614	7.795	(3.426)	0.026	2.214	(2.817)	0.435	4.252	(1.927)	0.029
Nov	-9.528	(6.869)	0.178	7.522	(4.382)	0.090	2.604	(5.000)	0.604	3.428	(2.235)	0.127
Dec	Ref.	(-)	(-)	Ref.	(-)	(-)	Ref.	(-)	(-)	Ref.	(-)	(-)
Age	-1.096	(0.337)	0.003	-2.036	(0.292)	0.000	-1.140	(0.317)	0.001	6.757	(0.792)	0.000
Birth order (first)	Ref.	(-)	(-)	Ref.	(-)	(-)	Ref.	(-)	(-)	Ref.	(-)	(-)
Second	138.141	(3.365)	0.000	147.233	(2.673)	0.000	136.990	(2.469)	0.000	146.427	(1.026)	0.000
Third	164.185	(3.942)	0.000	188.691	(5.322)	0.000	176.851	(3.227)	0.000	187.010	(2.484)	0.000
Fourth or higher	204.890	(8.405)	0.000	220.576	(7.512)	0.000	217.112	(6.066)	0.000	200.123	(3.226)	0.000
Education (primary)	Ref.	(-)	(-)	Ref.	(-)	(-)	Ref.	(-)	(-)	Ref.	(-)	(-)
Secondary	59.771	(4.255)	0.000	64.820	(4.435)	0.000	59.205	(6.456)	0.000	73.220	(4.046)	0.000
Tertiary	87.072	(4.434)	0.000	77.923	(3.533)	0.000	75.558	(6.641)	0.000	83.763	(2.836)	0.000
Period (1987-1996)	Ref.	(-)	(-)	Ref.	(-)	(-)	Ref.	(-)	(-)	Ref.	(-)	(-)
1997-2009	-33.760	(5.418)	0.000	-47.258	(3.241)	0.000	-38.554	(5.628)	0.000	-30.108	(3.582)	0.000
2010-2021	-58.087	(4.434)	0.000	-67.913	(5.050)	0.000	-57.872	(6.098)	0.000	-45.509	(1.898)	0.000
Cons	3486.429			3520.359			3535.896			3527.063		
Observa-tions	157,920			301,272			236,412			1,171,376		
Prob>F	0.0000			0.0000			0.0000			0.0000		
R-squared	0.0326			0.0356			0.0335			0.0327		

Finally, we apply mother fixed effects to control for unmeasured characteristics that are shared between siblings thus controlling for unobserved heterogeneity (Table 3). Estimates from the mother fixed effects models suggest peaks in January, February, March, and April (spring) and in September, October, and November (autumn). The spring peak ranges from 5.156 grams to 6.624 grams, with the highest weight observed in April. The autumn peak ranges from 3.657 grams to 5.303 grams, with the highest weight observed in October.

Table 3. *Results of mother fixed effects regression of birth weight on monthly dummies with December as the baseline.*

	All Finland		
Variables	**Coeff.**	**(SE)**	**P-value**
Jan	5.256	(1.717)	0.002
Feb	5.524	(1.750)	0.002
Mar	5.156	(1.696)	0.002
Apr	6.624	(1.710)	0.000
May	2.585	(1.704)	0.129
Jun	-1.761	(1.716)	0.305
Jul	1.751	(1.695)	0.302
Aug	0.657	(1.699)	0.699
Sep	3.761	(1.709)	0.028
Oct	5.303	(1.720)	0.002
Nov	3.657	(1.740)	0.036
Dec	Ref.	(-)	(-)
Age	-5.173	(0.162)	0.000
Birth order (first)	Ref.	(-)	(-)
Second	154.014	(0.816)	0.000
Third	199.231	(1.453)	0.000
Fourth or higher	230.483	(2.251)	0.000
Sex (male)	Ref.	(-)	(-)
Female	-140.382	(0.689)	0.000
Cons	3714.817		
Within	0.1011		
Between	0.0328		
Overall	0.0458		
Prob>F	0.0000		
Observations	1,866,980		
Groups	955,570		

Sensitivity analysis

We include two sensitivity analysis. First, we explore whether excluding induced births will show different results when applying mother fixed effects. The results show a similar pattern as our main analysis, with peaks in spring and autumn (Appendix, Table 4). Secondly, we apply mother fixed effects to explore gestational age after week 37 as the dependent variable to see whether the gestational age has a seasonal pattern. We observe gestational age to be longer in July, August, and September than the other months, a pattern which differs from the seasonal pattern in birth weight (Appendix, Table 5). We encourage future research to investigate the potential seasonal pattern and potential changes across time in gestational age by also including preterm births.

Discussion and conclusion

In this paper we studied seasonality of birth weight in singleton full-term births in Finland during a 35-year period using high-quality register data. We further examined how these seasonal patterns vary across time and within in the country.

Our analysis shows that since 1987 there has been a decrease in birth weight for singleton full-term infants. During the analysed period (1987–2021) we observed approximately 100 grams lower birth weight. This is in line with studies from the United States (Donahue et al., 2010; Morisaki et al., 2013; Oken, 2013) and South Korea (Hur, 2023). However, other countries have found either mixed results (Diouf et al., 2011) or an increase in birth weight across time (Ghosh et al., 2018; Olsen et al., 2023; Schack-Nielsen et al., 2006). A study by Sankilampi and colleagues (2013) shows an increase in mean birth weight in Finland between 1979–1983 and 1996–2008. Our study complements this study and we assume that there is a higher mean birth weight between 1987–1996 than both time periods (1979–1983 and 1996–2008) as presented by Sankilampi and colleagues, with a following decline. Mothers with more than one child have heavier babies, with the second child being between 174 and 187 grams (girls and boys respectively) heavier compared to the first born (Sankilampi et al., 2013). Although a fertility decline has been observed between 2010–2017 in Finland (Hellstrand et al., 2020), it remains unclear whether this factor contributes to the observed decrease in birth weight over time. It is also worth mentioning that seasonality in births tends to follow the same pattern as seasonality in birth weight with peaks in spring and autumn, as has been shown by Lam and Miron (1994).

Total fertility rate in Finland is the lowest among the Nordic countries with 1.37 in 2020 (Heino & Gissler, 2022). Maternal weight and pregnancy weight gain are often used as an explanation for an increase in birth weight (Schack-Nielsen et al., 2006). In Finland, mean pregnancy weight gain increased between 1960 and 2000 and has been reported to be associated with mean higher birth weight of the child (Kinnunen et al., 2003). However, the observed decrease of birth weight in Finland could also be linked to better screening of women with GDM. Overweight and obese mothers are more commonly diagnosed with GDM, and birth weight of children of obese women with GDM has decreased (Koivunen et al., 2017; Ellenberg et al., 2017). Furthermore, the observed decrease in Finland might be related to increased maternal age. In the last decades, the mean age of women giving birth and especially the proportion of women aged 35 and over giving birth have risen notably in Finland, and was highest among the Nordic countries in 2020 (Heino & Gissler, 2022). Additionally, a study of the Nordic countries (Finland, Sweden, Denmark, and Norway) showed that the risk of low birth weight and preterm birth increases with maternal age (Aradhya et al., 2023). We leave it to future studies to explore the mechanisms behind the observed decrease in birth weight in Finland.

Mean monthly birth weight shows a seasonal pattern in Finland, which is in line with previous research on seasonality in birth weight (Beltran et al., 2013; Chodick et al., 2009; Rantakallio, 1971). The highest birth weights were observed in spring and autumn and the lowest in summer and winter, similar to the suggested seasonal pattern for the Northern Hemisphere presented by Beltran et al. (2013). The observed seasonal pattern seems to be more pronounced for the period 1987–1996, and our analysis suggest that seasonal variation is not stable over time, as the pattern seems to diminish gradually during the study period. This could possibly be explained by factors related to changes in both maternal behaviour and birth management such as maternal age, total fertility rate, labour induction, and caesarean section, as has been the case in Finland (Heino & Gissler, 2022). The monthly seasonal pattern was also confirmed when we applied the regression models, with peaks in birth weight observed in spring and autumn. To explore the role of stable unmeasured characteristics that do not vary between siblings, we also applied mother fixed effects. Birth weights of siblings born in different months were compared, and also here we observed peaks in spring and autumn. This indicates that the seasonal pattern is more likely to be explained by factors that vary between siblings such as environmental conditions and pregnancy specific conditions, such as maternal stress. Environmental conditions could here be related to seasonal variations in temperature and hours of sunshine during pregnancy, while maternal stress could be related to the interaction between vulnerable trimesters and seasonal events e.g., summer and Christmas holidays or stochastic shocks faced during pregnancy. While our analysis is based on rich data, including information on maternal health during pregnancy, these data do not allow us to analyse such questions.

We further explored the seasonal pattern across Northern, Western Central, Eastern Central, and Southern Finland. There are differences between the regions, with on average higher mean monthly birth weight per month for the Western Central region and lowest for the Northern region. Our analyses indicate that the amplitude of the seasonal variability differs across regions. For instance, the Western Central region does not show any clear seasonal patterns in birth weight, while the Southern region fluctuates less than the Northern and Eastern Central regions (Figure 5 and Table 2). This could possibly be related to a more stable climate in the Western and Southern regions. Despite this, we also observe a peak in birth weight in spring in the Southern region. Comparing the Southern region with all of Finland we observe a similar magnitude, but the peak appears one month earlier. A spring peak is also observed in the Eastern Central region, with a substantively higher birth weight in April compared to December. A similarly substantive trough could also be observed in the Northern region in June. These large and substantive fluctuations in birth weight in the Northern and Eastern Central regions could possibly be explained by greater climate variations in these regions. Despite differences in population sizes among the regions, we believe that the substantial sample sizes across all regions ensure a minimal impact on our results.

The main strength of this study is the use of rich register data spanning a period of 35 years. In addition to the long follow up period, FMBR provides detailed, accurate data on infants with very little missing information. Further, the data allow us to apply mother fixed effects and control for unobserved maternal characteristics that are shared between siblings. Using sibling comparison design is an efficient way to reduce confounding bias, though it has its drawbacks. One downside is that analysis is restricted only to multi-child families, thus children from single-child families are excluded from the mother fixed effects analysis. Further, if the confounding factors are not completely shared by the children of the same mother, estimates from mother fixed effects models can be biased (Frisell et al., 2012; Sjölander et al., 2022). Hence, we are not able to control for unobserved time-varying confounders within the families such as changes in maternal health and health behaviours (see Aradhya et al., 2023). It is also a challenge if the outcome of one child affects subsequent fertility for younger siblings, and this could therefore bias our estimates (Aradhya et al., 2023). When interpreting results from the mother fixed effects models, these limitations have to be kept in mind. Further, although there are several advantages to large sample sizes, we are aware of the potential p-value problem. With large sample sizes p-values may reach statistical significance although the observed differences are minor and thus not necessarily clinically significant. Finally, we acknowledge that part of the variation in birth weight can be attributed to genetic factors and genetic regional differences (CHARGE Consortium Hematology Working Group et al., 2016), for instance between the western and eastern parts of Finland. However, assessing the potential role of (regional) genetic differences on birth weight are outside the scope of this study.

Further research is needed to fully disentangle the mechanisms behind the observed seasonality across different areas, regions and for instance climatic zones globally, but also more specifically in the Finnish context. It would also be of great interest to compare the findings of this paper with other Nordic countries such as Sweden and Norway, which share similar within-country variations in climate as Finland.

The mechanisms behind seasonality in birth weight are not fully understood. Some have suggested that seasonality of birth weight is a product of selection, and the association is driven by maternal and or family characteristics. In order to analyse whether the effect is driven by family characteristics we applied mother fixed effects models and compared birth weights of children born to the same mother in different months. Our analyses still show a clear seasonality in birth weight. Overall, we conclude that there is a clear seasonality in birth weight in Finland, and we suggest that the seasonality is more likely to be explained by varying environmental characteristics and, to a smaller degree, stable family socioeconomic characteristics.

References

Almond, D., Currie, J., & Duque, V. (2018). Childhood Circumstances and Adult Outcomes: Act II. *Journal of Economic Literature*, *56*(4), 1360–1446. https://doi.org/10.1257/jel.20171164

Aradhya, S., Tegunimataka, A., Kravdal, Ø., Martikainen, P., Myrskylä, M., Barclay, K., & Goisis, A. (2023). Maternal age and the risk of low birthweight and pre-term delivery: A pan-Nordic comparison. *International Journal of Epidemiology*, *52*(1), 156–164. https://doi.org/10.1093/ije/dyac211

Bakhtsiyarava, M., Grace, K., & Nawrotzki, R. J. (2018). Climate, Birth Weight, and Agricultural Livelihoods in Kenya and Mali. *American Journal of Public Health, 108*(S2), S144–S150. https://doi.org/10.2105/AJPH.2017.304128

Barker, D. J. P. (2004). The Developmental Origins of Adult Disease. *Journal of the American College of Nutrition, 23*(sup6), 588S–595S. https://doi.org/10.1080/07315724.2004.10719428

Becker, S. (1991). Seasonal Patterns of Births and Conception Throughout the World. In A. W. Zorgniotti (Ed.), *Temperature and Environmental Effects on the Testis* (Vol. 286, pp. 59–72). Springer US. https://doi.org/10.1007/978-1-4684-5913-5_6

Beltran, A., Wu, J., & Laurent, O. (2013). Associations of Meteorology with Adverse Pregnancy Outcomes: A Systematic Review of Preeclampsia, Preterm Birth and Birth Weight. *International Journal of Environmental Research and Public Health, 11*(1), 91–172. https://doi.org/10.3390/ijerph110100091

Black, S. E., Devereux, P. J., & Salvanes, K. G. (2007). From the Cradle to the Labor Market? The Effect of Birth Weight on Adult Outcomes. *The Quarterly Journal of Economics, 122*(1), 409–439. https://doi.org/10.1162/qjec.122.1.409

Calkins, K., & Devaskar, S. U. (2011). Fetal Origins of Adult Disease. *Current Problems in Pediatric and Adolescent Health Care, 41*(6), 158–176. https://doi.org/10.1016/j.cppeds.2011.01.001

CHARGE Consortium Hematology Working Group, Early Growth Genetics (EGG) Consortium, Horikoshi, M., Beaumont, R. N., Day, F. R., Warrington, N. M., Kooijman, M. N., Fernandez-Tajes, J., Feenstra, B., Van Zuydam, N. R., Gaulton, K. J., Grarup, N., Bradfield, J. P., Strachan, D. P., Li-Gao, R., Ahluwalia, T. S., Kreiner, E., Rueedi, R., Lyytikäinen, L.-P., … Freathy, R. M. (2016). Genome-wide associations for birth weight and correlations with adult disease. *Nature, 538*(7624), 248–252. https://doi.org/10.1038/nature19806

Chersich, M. F., Pham, M. D., Areal, A., Haghighi, M. M., Manyuchi, A., Swift, C. P., Wernecke, B., Robinson, M., Hetem, R., Boeckmann, M., & Hajat, S. (2020). Associations between high temperatures in pregnancy and risk of preterm birth, low birth weight, and stillbirths: Systematic review and meta-analysis. *BMJ*, m3811. https://doi.org/10.1136/bmj.m3811

Chodick, G., Flash, S., Deoitch, Y., & Shalev, V. (2009). Seasonality in Birth Weight: Review of Global Patterns and Potential Causes. *Human Biology, 81*(4), 463–477. https://doi.org/10.3378/027.081.0405

Chodick, G., Shalev, V., Goren, I., & Inskip, P. D. (2007). Seasonality in Birth Weight in Israel: New Evidence Suggests Several Global Patterns and Different Etiologies. *Annals of Epidemiology, 17*(6), 440–446. https://doi.org/10.1016/j.annepidem.2006.10.013

Currie, J., & Schwandt, H. (2013). Within-mother analysis of seasonal patterns in health at birth. *Proceedings of the National Academy of Sciences, 110*(30), 12265–12270. https://doi.org/10.1073/pnas.1307582110

Diouf, I., Charles, M. A., Blondel, B., Heude, B., & Kaminski, M. (2011). Discordant time trends in maternal body size and offspring birthweight of term deliveries in France between 1972 and 2003: Data from the French National Perinatal Surveys: Maternal weight and birthweight trends. *Paediatric and Perinatal Epidemiology, 25*(3), 210–217. https://doi.org/10.1111/j.1365-3016.2010.01188.x

Donahue, S. M. A., Kleinman, K. P., Gillman, M. W., & Oken, E. (2010). Trends in Birth Weight and Gestational Length Among Singleton Term Births in the United States: 1990–2005. *Obstetrics & Gynecology, 115*(2), 357–364. https://doi.org/10.1097/AOG.0b013e3181cbd5f5

Dorélien, A. (2019). The Effects of In Utero Exposure to Influenza on Birth and Infant Outcomes in the US. *Population and Development Review, 45*(3), 489–523. https://doi.org/10.1111/padr.12232

Ellenberg, A., Sarvilinna, N., Gissler, M., & Ulander, V. (2017). New guidelines for screening, diagnosing, and treating gestational diabetes – evaluation of maternal and neonatal outcomes in Finland from 2006 to 2012. *Acta Obstetricia et Gynecologica Scandinavica, 96*(3), 372–381. https://doi.org/10.1111/aogs.13074

Fong, K. C., Kosheleva, A., Kloog, I., Koutrakis, P., Laden, F., Coull, B. A., & Schwartz, J. D. (2019). Fine Particulate Air Pollution and Birthweight: Differences in Associations Along the Birthweight Distribution. *Epidemiology, 30*(5), 617–623. https://doi.org/10.1097/EDE.0000000000001039

Frisell, T., Öberg, S., Kuja-Halkola, R., & Sjölander, A. (2012). Sibling Comparison Designs: Bias From Non-Shared Confounders and Measurement Error. *Epidemiology, 23*(5). https://journals.lww.com/epidem/Fulltext/2012/09000/Sibling_Comparison_Designs__Bias_From_Non_Shared.11.aspx

Ghosh, R. E., Berild, J. D., Sterrantino, A. F., Toledano, M. B., & Hansell, A. L. (2018). Birth weight trends in England and Wales (1986–2012): Babies are getting heavier. *Archives of Disease in Childhood – Fetal and Neonatal Edition, 103*(3), F264–F270. https://doi.org/10.1136/archdischild-2016-311790

Grace, K., Verdin, A., Dorélien, A., Davenport, F., Funk, C., & Husak, G. (2021). Exploring Strategies for Investigating the Mechanisms Linking Climate and Individual-Level Child Health Outcomes: An Analysis of Birth Weight in Mali. *Demography, 58*(2), 499–526. https://doi.org/10.1215/00703370-8977484

Ha, S., Zhu, Y., Liu, D., Sherman, S., & Mendola, P. (2017). Ambient temperature and air quality in relation to small for gestational age and term low birthweight. *Environmental Research, 155*, 394–400. https://doi.org/10.1016/j.envres.2017.02.021

Hajdu, T., & Hajdu, G. (2021). Temperature, climate change, and birth weight: Evidence from Hungary. *Population and Environment, 43*(2), 131–148. https://doi.org/10.1007/s11111-021-00380-y

Heino, A., & Gissler, M. (2022). Nordic perinatal statistics 2020–*Caesarean sections became more common in Finland and Sweden* (Statistical Report 11/2022). Finnish Institute for Health and Welfare (THL). https://www.julkari.fi/bitstream/handle/10024/144265/Nordic_perinatal_statistic_2020.pdf?sequence=1&isAllowed=y

Hellstrand, J., Nisén, J. & Myrskylä, M. (2020) All-time low period fertility in Finland: Demographic drivers, tempo effects, and cohort implications. *Population Studies, 74*(3), 315–329. https://doi.org/10.1080/00324728.2020.1750677

Hur, Y.-M. (2023). Secular Trends of Birth Weight in Twins and Singletons in South Korea from 2000 to 2020. *Twin Research and Human Genetics*, 1–6. https://doi.org/10.1017/thg.2023.16

Jensen, C. B., Gamborg, M., Raymond, K., McGrath, J., Sørensen, T. I. A., & Heitmann, B. L. (2015). Secular trends in seasonal variation in birth weight. *Early Human Development, 91*(6), 361–365. https://doi.org/10.1016/j.earlhumdev.2015.03.010

Kinnunen, T. I., Luoto, R., Gissler, M., & Hemminki, E. (2003). Pregnancy weight gain from 1960s to 2000 in Finland. *International Journal of Obesity, 27*(12), 1572–1577. https://doi.org/10.1038/sj.ijo.0802471

Koivunen, S., Torkki, A., Bloigu, A., Gissler, M., Pouta, A., Kajantie, E., & Vääräsmäki, M. (2017). Towards national comprehensive gestational diabetes screening – consequences for neonatal outcome and care. *Acta Obstetricia et Gynecologica Scandinavica, 96*(1), 106–113. https://doi.org/10.1111/aogs.13030

Kuehn, L., & McCormick, S. (2017). Heat Exposure and Maternal Health in the Face of Climate Change. *International Journal of Environmental Research and Public Health, 14*(8), 853. https://doi.org/10.3390/ijerph14080853

Lam, D. A., & Miron, J. A. (1994). Global Patterns of Seasonal Variation in Human Fertility. *Annals of the New York Academy of Sciences, 709*(1), 9–28. https://doi.org/10.1111/j.1749-6632.1994.tb30385.x

Liu, X., Behrman, J., Hannum, E., Wang, F., & Zhao, Q. (2022). Same environment, stratified impacts? Air pollution, extreme temperatures, and birth weight in South China. *Social Science Research, 105*, 102691. https://doi.org/10.1016/j.ssresearch.2021.102691

Morisaki, N., Esplin, M. S., Varner, M. W., Henry, E., & Oken, E. (2013). Declines in Birth Weight and Fetal Growth Independent of Gestational Length: *Obstetrics & Gynecology, 121*(1), 51–58. https://doi.org/10.1097/AOG.0b013e318278d014

Oken, E. (2013). Secular Trends in Birthweight. In M. W. Gillman, P. D. Gluckman, & R. G. Rosenfeld (Eds.), *Nestlé Nutrition Institute Workshop Series* (Vol. 71, pp. 103–114). S. Karger AG. https://doi.org/10.1159/000342576

Olsen, S. H., Reynstind, D., Hallgrímsson, H., & Kesmodel, U. S. (2023). Birthweight and gestational age in the Faroe Islands: A comparison between birthweight and gestational age in the Faroe Islands and other Nordic countries. *Acta Obstetricia et Gynecologica Scandinavica, 102*(4), 506–515. https://doi.org/10.1111/aogs.14527

Poursafa, P., Keikha, M., & Kelishadi, R. (2015). Systematic review on adverse birth outcomes of climate change. *Journal of Research in Medical Sciences: The Official Journal of Isfahan University of Medical Sciences, 20*(4), 397.

Rantakallio, P. (1971). The effect of a northern climate on seasonality of births and the outcome of pregnancies. *Acta Paediatrica Scandinavica Supplement, 21*8, 1–67.

Sankilampi, U., Hannila, M.-L., Saari, A., Gissler, M., & Dunkel, L. (2013). New population-based references for birth weight, length, and head circumference in singletons and twins from 23 to 43 gestation weeks. *Annals of Medicine, 45*(5–6), 446–454. https://doi.org/10.3109/07853890.2013.803739

Schack-Nielsen, L., Mølgaard, C., Sørensen, T. I. A., Greisen, G., & Michaelsen, K. F. (2006). Secular Change in Size at Birth from 1973 to 2003: National Data from Denmark. *Obesity, 14*(7), 1257–1263. https://doi.org/10.1038/oby.2006.143

Sjölander, A., Frisell, T., & Öberg, S. (2022). Sibling Comparison Studies. *Annual Review of Statistics and Its Application, 9*(1), 71–94. https://doi.org/10.1146/annurev-statistics-040120-024521

Strand, L. B., Barnett, A. G., & Tong, S. (2011). The influence of season and ambient temperature on birth outcomes: A review of the epidemiological literature. *Environmental Research, 111*(3), 451–462. https://doi.org/10.1016/j.envres.2011.01.023

Torche, F., & Conley, D. (2016). A Pound of Flesh: The Use of Birthweight as a Measure of Human Capital Endowment in Economics Research. In J. Komlos & I. R. Kelly (Eds.), *The Oxford handbook of economics and human biology* (pp. 632–649). Oxford University Press.

Torche, F., & Corvalan, A. (2010). Seasonality of Birth Weight in Chile: Environmental and Socioeconomic Factors. *Annals of Epidemiology, 20*(11), 818–826. https://doi.org/10.1016/j.annepidem.2010.08.005

Tustin, K., Gross, J., & Hayne, H. (2004). Maternal exposure to first-trimester sunshine is associated with increased birth weight in human infants. *Developmental Psychobiology, 45*(4), 221–230. https://doi.org/10.1002/dev.20030

Appendix

Table 1. *Number of observations and information on birth weight by regions in Finland.*

Region	Observations	Mean birth weight	Standard deviation (birth weight)
Northern	157,920	3581.53	472.65
Eastern Central	301,272	3596.39	473.75
Western Central	236,412	3639.58	473.82
Southern	1,171,376	3594.80	473.04
Total	**1,866,980**	**3599.61**	**473.48**

Table 2. *Overview of the four regions in Finland used for our analysis.*

Southern	Western Central	Eastern Central	Northern
Uusimaa	Central Ostrobothnia	Kainuu	Lapland
Southwest	Ostrobothnia	North Savo	Kuusamo (municipality)
Satakunta	South Ostrobothnia	North Karelia	Taivalkoski (municipality)
Kanta-Häme	Utajärvi (municipality)	Central Finland	Pudasjärvi(municipality)
Pirkanmaa	Muhos (municipality)	South Savo	Yli-II (municipality)
Päijät-Häme	Kempele (municipality)		Haukipudas (municipality)
Kymenlaakso	Hailuoto (municipality)		Kiiminki (municipality)
South Karelia	Lumijoki (municipality)		Oulusalo (municipality)
Åland	Liminka (municipality)		Oulu (municipality)
	Tyrnävä (municipality)		
	Raahe (municipality)		
	Siikajoki (municipality)		
	Siikalatva (municipality)		
	Vihanti (municipality)		
	Pyhäntä (municipality)		
	Pyhäjoki (municipality)		
	Merijärvi (municipality)		
	Oulainen (municipality)		
	Haapavesi (municipality)		
	Kärsämäki (municipality)		
	Kalajoki (municipality)		
	Alavieska (municipality)		
	Ylivieska (municipality)		
	Nivala (municipality)		
	Haapajärvi (municipality)		
	Pyhäjärvi (municipality)		
	Sievi (municipality)		
	Reisjärvi (municipality)		
	Vaala (municipality)		

Table 3. *Number of full-term singleton births by month from 1987 to 2021.*

Month	Frequency	Percent
January	155 417	8.32
February	144 335	7.73
March	162 755	8.72
April	157 023	8.41
May	159 763	8.56
June	155 730	8.34
July	163 600	8.76
August	161 970	8.68
September	157 984	8.46
October	153 839	8.24
November	146 744	7.86
December	147 820	7.92
Total	**1 866 980**	**100**

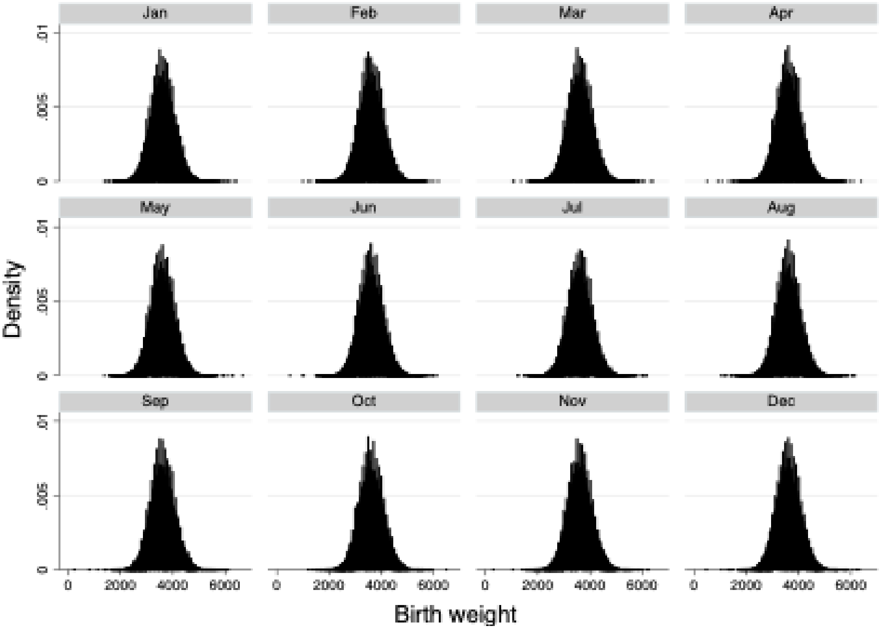

Figure 1. *Birth weight distributions by month. Full-term singleton births from 1987 to 2021.*

Table 4. *Results of mother fixed effects regression results of birth weight on monthly dummies with December as the baseline without induced births.*

	All Finland		
Variables	**Coeff.**	**(SE)**	**P-value**
Jan	3.179	(1.945)	0.102
Feb	4.069	(1.981)	0.040
Mar	5.348	(1.920)	0.005
Apr	3.971	(1.937)	0.040
May	0.711	(1.929)	0.712
Jun	-2.914	(1.943)	0.134
Jul	1.046	(1.918)	0.585
Aug	-0.241	(1.925)	0.900
Sep	3.285	(1.936)	0.090
Oct	4.292	(1.952)	0.028
Nov	2.223	(1.971)	0.259
Dec	Ref.	(-)	(-)
Age	-4.395	(0.190)	0.000
Birth order (first)	Ref.	(-)	(-)
Second	152.895	(0.932)	0.000
Third	200.155	(1.662)	0.000
Fourth or higher	235.874	(2.581)	0.000
Sex (male)	Ref.	(-)	(-)
Female	-138.827	(0.782)	0.000
Cons	3678.757		
Within	0.1086		
Between	0.0346		
Overall	0.0463		
Prob>F	0.0000		
Observations	1,521,044		
Groups	852,396		

Table 5. *Results of mother fixed effects regression of gestational age in days after week 37 on monthly dummies with December as the baseline.*

	All Finland		
Variables	**Coeff.**	**(SE)**	**P-value**
Jan	0.136	(0.035)	0.000
Feb	0.111	(0.036)	0.002
Mar	0.177	(0.035)	0.000
Apr	0.178	(0.035)	0.000
May	0.187	(0.035)	0.000
Jun	0.161	(0.035)	0.000
Jul	0.208	(0.035)	0.000
Aug	0.269	(0.035)	0.000
Sep	0.193	(0.035)	0.000
Oct	0.187	(0.035)	0.000
Nov	0.143	(0.035)	0.000
Dec	Ref.	(-)	(-)
Age	-0.114	(0.003)	0.000
Birth order (first)	Ref.	(-)	(-)
Second	-0.373	(0.017)	0.000
Third	-0.435	(0.030)	0.000
Fourth or higher	-0.931	(0.046)	0.000
Sex (male)	Ref.	(-)	(-)
Female	0.223	(0.014)	0.000
Cons	24.646		
Within	0.0115		
Between	0.0024		
Overall	0.0042		
Prob>F	0.0000		
Observations	1,866,980		
Groups	955,570		