



## ORIGINAL ARTICLE

# Influence of sociodemographic factors in birth seasonality in Spain

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## Abstract

**Objectives:** The goal of the present research is to establish for the first time a hierarchy of sociodemographic factors according to their importance influencing birth seasonality.

**Methods:** We used Vital Statistics data on all births registered in Spain in the period 2016–2019. Differences in the degree of seasonality between sociodemographic groups (defined by maternal age, maternal marital status, maternal education, birth order, maternal job qualification, maternal employment status, maternal location population size, and maternal country of birth) were first examined with descriptive techniques. Secondly, analysis through alternative Data Mining techniques determined the association between sociodemographic factors and birth seasonality and the factors importance rank.

**Results:** Those factors related to maternal labor status (employment status, job qualification, and education) were found to be the most relevant influencing birth seasonality. It was found that the overall seasonal pattern in Spain was driven by lower skilled employed mothers, in contrast with not employed or high skilled employed mothers, who showed a different or weaker seasonality. Finally, we found that a change in the rhythm pattern has taken place in the last decades in Spain.

**Conclusions:** Birth seasonality is to a large extent related to maternal employment status. Employed mothers, normally more affected by the seasonality of work calendar than the unemployed, show higher conception rates structured around holidays. This may indicate that the observed change of seasonal pattern in Spain in the last decades, as in other European countries, may be specifically driven by the progressive higher participation of women in labor market.

## 1 | BACKGROUND

The number of births varies markedly by season showing a seasonal pattern in most human populations, but the

patterns are not identical in all regions. For several periods of the 20th century, most European countries showed a birth peak in the spring and low birth rates in the autumn, while some US states, Canada, Israel,

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South Africa, and New Zealand showed patterns with high birth rates during the summer and autumn (Lam & Miron, 1994). The seasonal patterns also may vary in different periods within the same country: a decline of birth seasonality is shown in Sweden during the 21st century (Dahlberg & Andersson, 2018) and in Spain from 1941 to 2000 (Cancho-Candela et al., 2007) and a change of pattern is shown in Italy (Ruiu & Breschi, 2020), Germany (Lerchl et al., 1993), UK and other European locations (Cummings, 2009).

Several studies have found that month of birth is frequently associated with later outcomes in life such as mortality (Ueda et al., 2013), lifespan (Doblhammer & Vaupel, 2001), number of live-born children (Huber et al., 2004), health (Lokshin & Radyakin, 2009; Reffellmann et al., 2011), and childhood disease dynamics (Martinez-Bakker et al., 2014).

Although frequently studied, the causes of human birth seasonality are still not fully understood. The proposed explanations include environmental, biological, and sociocultural factors that ultimately affect the two primary factors that are the main drivers of birth seasonality: seasonal sexual activity and seasonal fertility. The environmental factors comprise photoperiod, temperature, humidity (Barreca et al., 2018; Cummings, 2010; Lam & Miron, 1996; Roenneberg & Aschoff, 1990) and availability of food (Kowalewski & Zunino, 2004) that can affect semen quality and ovulation rate (Centola & Eberly, 1999; Gyllenberg et al., 1999; Rojansky et al., 1992). Among biological factors fetal loss seasonality (Weinberg et al., 1994) and seasonal fertility (Symul et al., 2020) have been advanced as factors that may underlie the seasonality of births. Various social and cultural factors have also been studied such as seasonal fluctuations in coital rates (Udry & Morris, 1967), increased sexual activity around holidays (Symul et al., 2020), seasonality in marriages (Grech et al., 2003; Stolwijk et al., 1996) and contraception and family planning (Bobak & Gjonca, 2001; Dahlberg & Andersson, 2019; Haandrikman & Van Wissen, 2008; Régnier-Loilier & Wiles-Portier, 2010). Even though the question of whether seasonal sexual activity or seasonal fertility, as primary factors, drive birth seasonality has remained open and difficult to test without large-scale data on sexual activity, a recent study suggests that birth seasonality is primarily driven by seasonal fertility, although increased sexual activity around holidays explains minor peaks in the birth curve (Symul et al., 2020).

Another set of factors that have been studied are the sociodemographic characteristics of mothers, such as maternal education, age, parity, re-partnering, race, social class, birth order, or legitimacy. Among the sociodemographic factors it has been found that in Sub-

Saharan Africa, 1987–2008, birth patterns vary with levels of maternal education, religion and residence (i.e. urban vs. rural) where mothers with lower levels of education and those residing in rural areas exhibited greater seasonal fluctuations in births (Dorélien, 2016). In Sweden, where most births between 1940 and 1999 took place during the spring, the seasonal variation was most pronounced among mothers with higher education, aged 25–29, with their second order birth and who had not re-partnered (Dahlberg & Andersson, 2018). In Czech Republic, where most births took place during the spring between years 1989–1991, the seasonal variation of births was highly pronounced in mothers who were 25–34 years old, had higher education, were married and were pregnant with their second or third child (Bobak & Gjonca, 2001). However, in previous articles, most of them referring to Northern European countries, the importance of the different sociodemographic variables has not been calibrated.

In Spain, a decline and loss of birth seasonality was found in 1940–2000 (Cancho-Candela et al., 2007). To what extent can sociodemographic factors explain birth seasonal patterns in Spain and which of them influence birth seasonality the most? To what extent changes in women's sociodemographic characteristics during 1940–2000, such as women increase in labor participation or maternal increasing age, can explain the observed change in the birth pattern? Our hypothesis is that the rhythm of sexual intercourse is to a large extent related with maternal sociodemographic characteristics, being employment related characteristics the sociodemographic factors that differentially affect the rhythm of sexual intercourse, ultimately affecting birth seasonality. Under this hypothesis, changes in employment maternal characteristics would ultimately translate in changes in the birth seasonal pattern, as the observed in Spain in the last decades of the 20th century (Cancho-Candela et al., 2007) and those observed in other European countries from 1975 to 2005 (Régnier-Loilier & Divinagracia, 2010).

Our aim is to study the sociodemographic factors that may explain birth seasonality in a Southern European country in the period 2016–2019, establishing for the first time a hierarchy of those factors to test whether those related to women's employment status are affecting birth seasonality the most.

## 2 | METHODS

A time series composed of 1 510 817 births in Spain in the period 2016–2019 was analyzed. The data come from the Birth Statistics of Vital Statistics elaborated by the National Institute of Statistics (Instituto Nacional de

Estadística, 2020). Vital Statistics collects all births that occur in Spain, including undocumented migrants, regardless of whether the mothers are residents or non-residents. In the public dataset the month of birth is the most detailed temporal variable available.

The following maternal characteristics were considered in this study: maternal age, maternal marital status, maternal education, birth order, maternal job qualification, maternal employment status, maternal location population size and maternal country of birth. Maternal age was classified into the following groups: <20, 20–24, 25–29, 30–34, and >34. Two categories of maternal marital status were used: married and unmarried (in this last category single, separated/divorced and widow were included). Mothers were classified into three categories of education: low (corresponding to primary/compulsory school), medium (higher bachelor) and high (university). Birth order was categorized into four groups: 1st, 2nd, 3rd, and 4th or higher. Maternal job qualification was classified into two groups: low qualification and high qualification. Maternal employment status was only available in the statistics from 2018 onwards and was organized in two categories: employed and other. Two categories of maternal location population size were used: populations with less than 100 000 habitants and populations with 100 000 or higher. Finally, mothers were classified into two categories of country of birth: Spain and other country.

When applying multivariate data analysis, a missing value in one variable eliminates the entire observation. Thus, when the proportion of missing values is high, imputation is necessary to obtain representative results that are not biased by missing data (López, 2004). As the information presented missing values in some of the variables used (6% in maternal education, 1% in maternal country of birth and 38% in job qualification), the data set was imputed following a fully conditional specification (FCS) approach in order not to lose 40% of the cases in the analysis. For a data set with an arbitrary missing data pattern, FCS methods can be used to impute missing values for all variables, assuming the existence of a joint distribution for these variables when no convenient and realistic joint distribution can be specified (Van Buuren, 2007). The imputation procedure was performed using the statistical software package SAS 9.4.

Seasonality of births was analyzed as follows. First, the occurrence of seasonal rhythm of births was assessed with the Chi-square test, being the expected number of births in each month proportional to the month length. Then, the existence of an averaged pattern of seasonality that regularly repeats each year was confirmed with the results shown in the periodogram. Second, the monthly series of observed/expected number of births was built

correcting for the different numbers of days by month and the outcome was examined by visual inspection. Whereas Box-Jenkins time series methodology recommends at least 50 observations to apply time series methods (López, 2011), the observed series including the variable maternal employment status, only available in 2018–2019, has 24 observations. Once the time series methodology has been discarded and taking into account that observed/expected number of births were similar in all calendar years, the data were pooled. Third, we measured the extent of the seasonal variation by calculating the coefficient of variation between the 12 months for all births and separately according to sociodemographic characteristics. Fourth, in each sociodemographic category, we calculated the ratio of the number of births in the month with the most and least births. Fifth, we examined the independent contribution of the individual factors to seasonal variation by building a logistic regression model on data restricted to high and low birth rate periods (August to October and March to May). The outcome variable was period of birth (being born in August to October was coded as 1 and being born on March to May was coded as 0) and maternal age, education, marital status, birth order, job qualification, employment status, population size and country of birth were the independent variables.

Finally, alternative Data Mining techniques to the logistic regression model determined the association between sociodemographic factors and birth seasonality as well as the factors importance rank: discriminant analysis, CHAID decision tree, Radial Basis Neural Networks, and Bayesian Networks. As in the case of logistic regression, the alternative Data Mining techniques considered are intended to classify and predict the category of the qualitative outcome variable (high or low birth seasonality) in which individuals of a population are classified according to the values of their qualitative independent variables (sociodemographic factors). In discriminant analysis, the classification and prediction of the category is carried out by determining one or more mathematical functions, called Fisher's discriminant functions, which allow the classification of new cases from the information we have about them (Pérez López & Santín González, 2007). The CHAID decision tree (Chi-square Automatic Interaction Detector) method is a highly efficient statistical technique for segmentation. (Kass, 1980). Using the significance of a  $\chi^2$  test as a criterion, CHAID evaluates all the values of a potential predictor field. It merges values that are judged to be statistically homogeneous (similar) with respect to the target variable and maintains all other values that are heterogeneous (dissimilar). It then selects the best predictor to form the first branch in the decision tree, such that each child node is

made of a group of homogeneous values of the selected field. This process continues recursively until the tree is fully grown (IBM Corporation, 2016). Neural Networks are a set of highly interconnected information processing elements, which are able to learn with the information that is introduced to them (Pérez, 2014) and can be applied to a large number of problems, including classification and discrimination, as is our case. A radial basis function (RBF) network is a feed-forward, supervised learning network with only one hidden layer, called the radial basis function layer. The RBF network is a function of one or more predictors that minimizes the prediction error of one or more targets. Predictors and targets can be a mix of categorical and continuous fields (IBM Corporation, 2016). Finally, a Bayesian Network provides a succinct way of describing the joint probability distribution for a given set of random variables. The model is an improvement over the naïve Bayes model as it allows for each predictor to depend on another predictor in addition to the target variable (IBM Corporation, 2016).

The importance of the predictors (factors) can be determined by computing the reduction in variance of the target attributable to each predictor, via a sensitivity analysis, using the Variance Based Method (Salteli et al., 2004). This predictor importance algorithm can be used in all the techniques considered in this study: Neural Networks, CHAID, Logistic, Discriminant and Bayesian Networks (IBM Corporation, 2016).

As maternal employment status is only available in the statistics from 2018 onwards, data mining techniques to determine factors importance were only applied to period 2018–2019. Data mining was performed using the statistical software package IBM SPSS Modeler 18.0.

## 2.1 | Ethical concerns

Retrospective, secondary, anonymized datasets from Spanish National Statistics Office were used for the purpose of the present study. The Ethics Committee of Research and Animal Experimentation of the University of Alcalá exempted this research from ethical review because involved non-identifiable data and datasets are in the public domain.

## 3 | RESULTS

Table 1 shows monthly ratios of observed/expected numbers of birth by calendar year, where the observed/expected monthly numbers of births ( $\times 100$ ) were calculated after correction for the unequal numbers of days. The Chi-square values for the monthly number of births (degrees of freedom = 11) were 567, 358, 304 and 365 in 2016–2019 respectively, confirming that the differences in the number of births between months are significant ( $p < .001$ ). Based on the results shown in the periodogram (Figure A1 in the Appendix), the existence of an averaged pattern of seasonality that regularly repeats each year was confirmed as the second peak of the periodogram is placed at 0.083 (1/12), revealing a significant periodicity of 12 months. Seasonal rhythm was found, with most births occurring in August–October and minimum birth rates in March to May. Table 2 shows monthly ratios of observed/expected numbers of birth by socio-demographic characteristics during the period 2016–19. Figures 1–9 show the observed/expected numbers of births for the total births and by

TABLE 1 Absolute and observed/expected numbers of births by month and year

Month of birth	All births 2016–2019		2016		2017		2018		2019	
	Abs. No.	Obs/Exp	Abs. No.	Obs/Exp	Abs. No.	Obs/Exp	Abs. No.	Obs/Exp	Abs. No.	Obs/Exp
January	127 557	99.5	33 756	98.9	32 096	97.9	31 216	100.2	30 489	101.1
February	115 353	98.7	31 456	98.6	29 202	98.6	27 685	98.4	27 010	99.1
March	124 819	97.3	33 642	98.6	32 278	98.4	29 864	95.9	29 035	96.2
April	119 198	96.1	31 231	94.6	30 337	95.6	29 069	96.5	28 561	97.8
May	125 017	97.5	32 786	96.1	32 250	98.3	30 548	98.1	29 433	97.6
June	123 144	99.2	33 451	101.3	31 458	99.1	30 010	99.6	28 225	96.7
July	131 536	102.6	35 162	103.1	33 392	101.8	31 982	102.7	31 000	102.7
August	132 539	103.4	35 621	104.4	33 472	102.1	32 541	104.5	30 905	102.4
September	130 466	105.1	35 535	107.6	33 158	104.5	30 964	102.8	30 809	105.5
October	133 398	104.0	34 993	102.6	34 362	104.8	32 448	104.2	31 595	104.7
November	124 918	100.7	32 712	99.1	32 744	103.2	30 150	100.1	29 312	100.4
December	122 872	95.8	32 460	95.1	31 384	95.7	30 152	96.8	28 876	95.7
Total	1510 817		4,02805		386 133		366 629		355 250	

TABLE 2 Ratio of observed/expected number of births by month and sociodemographic variables, 2016–2019

Month of birth	Maternal age					Birth order				Maternal education		
	<20	20–24	25–29	30–34	35+	1st	2nd	3rd	4th+	Low	Medium	High
January	102.2	98.9	98.5	99.1	100.2	100.0	99.1	99.1	98.3	101.5	95.6	101.6
February	100.9	96.8	97.3	98.3	99.9	98.3	99.8	97.3	96.3	97.7	97.5	101.0
March	95.4	95.7	95.9	98.0	97.8	97.1	99.1	93.9	91.4	95.8	95.2	101.1
April	96.2	90.8	95.3	98.0	95.7	93.9	100.0	93.0	92.8	91.9	95.5	100.7
May	93.2	95.3	97.8	99.1	96.6	94.1	102.4	96.8	92.8	94.2	98.4	99.7
June	101.0	102.0	99.6	99.5	98.2	98.6	100.1	99.3	98.1	99.1	100.0	98.4
July	102.2	103.6	103.9	103.2	101.3	103.3	101.5	102.4	104.8	102.4	104.0	101.1
August	103.5	105.1	104.5	103.5	102.4	104.8	101.0	104.1	106.3	105.0	104.1	100.8
September	105.5	108.3	108.5	105.6	102.7	105.3	104.1	107.9	106.6	106.8	106.1	102.4
October	100.5	104.9	104.5	103.2	104.5	105.0	102.2	106.1	104.8	104.9	105.0	102.0
November	100.0	101.6	98.9	99.3	102.5	102.0	98.3	102.1	104.3	101.6	103.1	97.0
December	99.6	96.9	95.0	93.1	98.1	97.5	92.5	97.8	103.3	98.9	95.2	93.3

Month of birth	Maternal marital status		Town size		Maternal job qualification		Maternal country of birth		Maternal employment status <sup>a</sup>	
	Married	Not married	Small	Big	Low	High	Spain	Other	Employed	Other
January	99.0	100.1	100.2	99.2	98.6	100.5	99.9	98.2	95.4	110.0
February	99.1	98.3	98.6	98.8	97.4	100.3	99.4	96.8	95.3	105.0
March	98.1	96.5	96.5	97.7	95.2	100.0	98.7	93.5	93.9	100.0
April	97.7	94.2	94.6	96.7	92.8	100.1	97.6	91.6	97.0	97.4
May	100.0	94.6	96.6	97.9	95.4	100.1	98.4	94.9	98.3	97.0
June	101.3	96.9	99.2	99.3	98.9	99.6	98.9	100.2	98.3	97.9
July	103.6	101.4	102.4	102.7	103.0	102.1	102.1	104.1	103.7	101.0
August	102.9	103.8	104.2	103.0	105.1	101.3	102.7	105.3	105.1	100.6
September	103.7	106.8	105.7	104.9	106.7	103.2	104.5	107.0	105.8	101.2
October	103.1	105.1	105.0	103.6	105.9	101.8	103.4	105.7	106.8	100.3
November	98.6	102.9	100.5	100.7	102.8	98.0	100.2	102.1	102.4	96.3
December	92.8	99.2	96.6	95.5	98.1	93.0	94.3	100.2	97.8	93.6

<sup>a</sup>Variable only available for years 2018–2019.

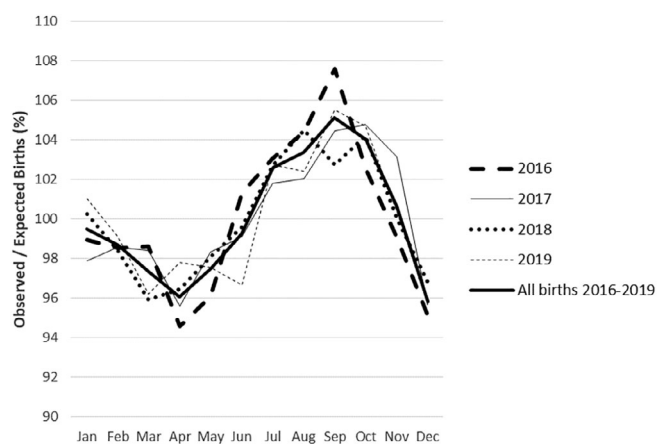
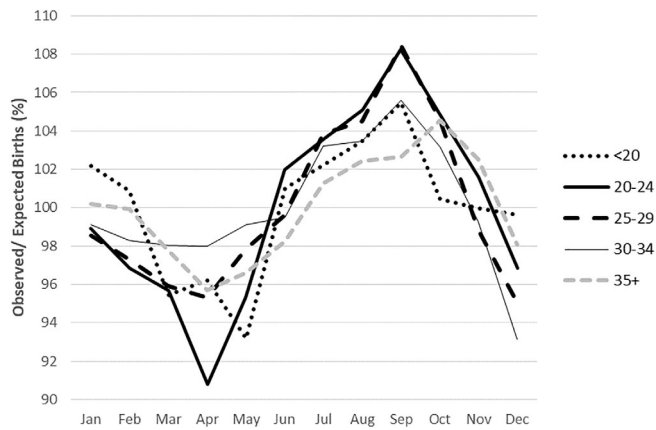
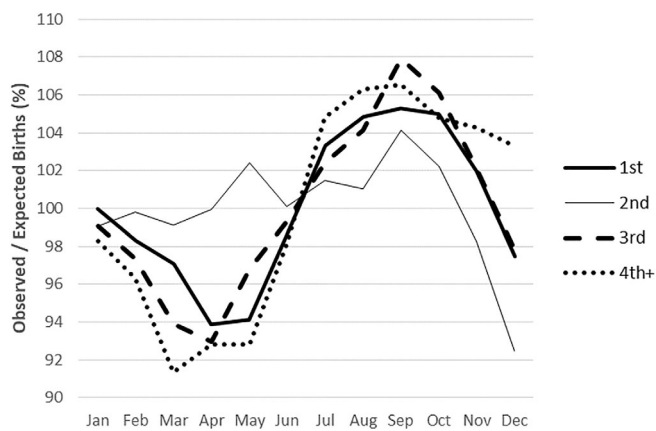


FIGURE 1 Seasonal variation in births, years 2016–2019

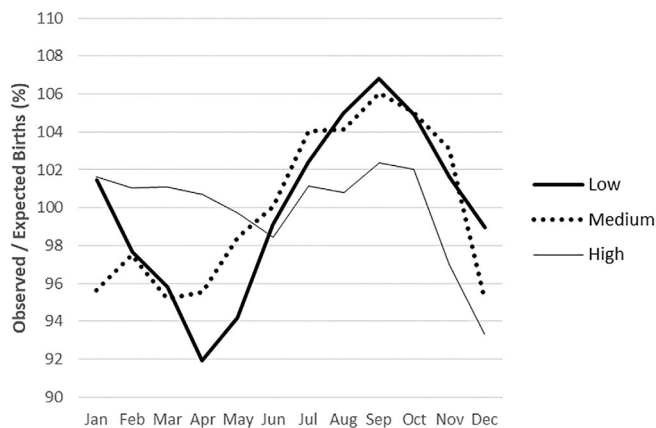
sociodemographic characteristics. During 2016–2019 most births occur in August–October whereas the minimum birth rates are in March to May, but the curve is bimodal, with a secondary birth trough in November and December and a second birth spike in January (Figure 1). The seasonal curves are relatively flat for births of mothers 30–34 years old, and it was highly pronounced in mothers aged 20–24 years (Figure 2). There are also differences by birth order: seasonal pattern was smallest for second-born infants and largest for children born as fourth or more (Figure 3). Maternal education also had an influence on the month of births; the seasonal variation was minimal among mothers with higher education level and highly pronounced with lower education (Figure 4). By marital status there were also differences;



**FIGURE 2** Seasonal variation in births by maternal age group

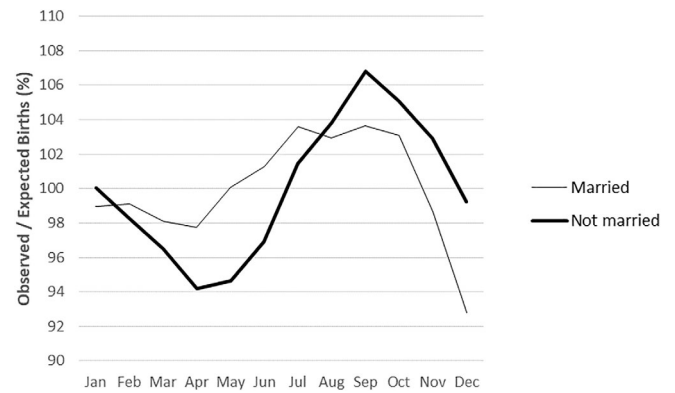


**FIGURE 3** Seasonal variation in births by birth order

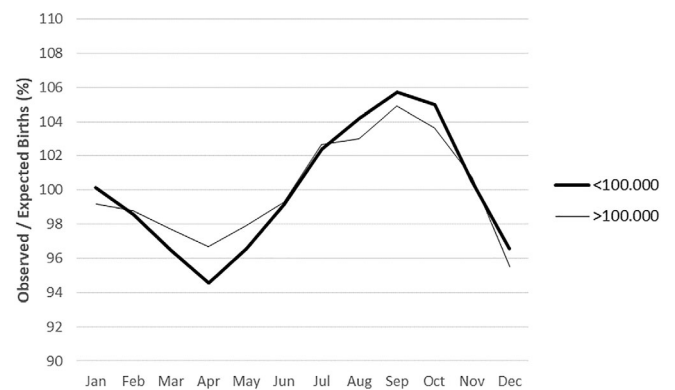


**FIGURE 4** Seasonal variation in births by maternal education

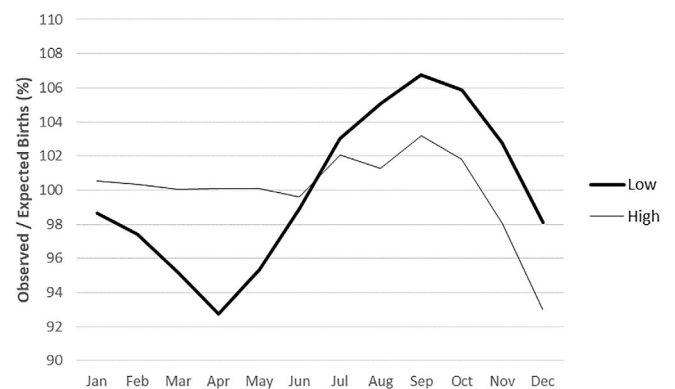
while for not married mothers (single, separated or widow) the seasonal pattern was highly pronounced, it was less pronounced for married mothers (Figure 5). Women giving birth in towns with less than 100 000 habitants showed a stronger seasonal pattern than those giving birth in towns of 100 000 habitants or more



**FIGURE 5** Seasonal variation in births by maternal marital status



**FIGURE 6** Seasonal variation in births by maternal town size

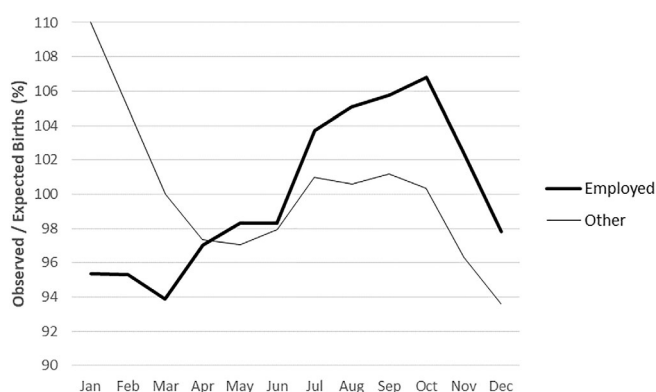


**FIGURE 7** Seasonal variation in births by maternal job qualification

(Figure 6). Maternal job qualification also had an influence on the month of births; the seasonal variation was smallest among mothers with higher job qualification level and highly pronounced with lower job qualification (Figure 7). There were also differences by maternal country of birth; seasonal pattern was smallest for mothers who were born in Spain and largest for mothers born in



**FIGURE 8** Seasonal variation in births by maternal country of birth



**FIGURE 9** Seasonal variation in births by maternal employment status. Only 2018–2019

another country (Figure 8). Finally, employed mothers showed a highly differentiated seasonal pattern from those mothers who were in a different category (Figure 9). Furthermore, the variable maternal employment status considers the following categories in data that are distributed as follows in 2018–2019: employed (64.0%), unemployed (15.4%), economically inactive (17.6%), permanently disabled (0.3%), student (1.2%) and “not recorded or people who cannot be classified” (1.5%). Although in Figure 9 this variable is organized in two categories -employed (64.0%) and others (36.0%)—the analysis through all the available original categories (Figures A2–A7 in the Appendix) reveals consistency, lack of reporting anomalies and two differentiated behaviors: on the one hand unemployed mothers and economically inactive mothers perform similarly with a high birth peak in January–March that steadily decreases (Figures A4 and A5). Instead, employed and student mothers, who also perform similarly, behave quite differently from unemployed and economically inactive mothers, with a birth peak around September (Figures A2 and A3). Besides, for employed mothers it is

remarkable the effect of the educational level (Figure A2). The different seasonal pattern of the permanently disabled category seems to be due to the lower number of cases, but is still similar to the unemployed and economically inactive category (Figure A6). Finally, in case of misreporting, the birth is registered in the “not recorded or people who cannot be classified” category that accounts only for 1.5% of the total cases, presenting an averaged birth seasonality pattern that reminds of the general pattern in Figure 1 (Figure A7).

Furthermore, figures show that the low seasonality social group for each sociodemographic factor is more likely to give birth in the spring and less likely to give birth at the end of the year (Figures 2–8).

The seasonal variation by sociodemographic variables is shown in Table 3. Both indicators of the seasonal variation, the coefficient of variation and the ratio of the numbers of birth in the month with the largest versus the lowest number of births, confirm the pattern seen in Figures 2–9.

Furthermore, we studied the crude and adjusted associations between sociodemographic variables and birth seasonality (Table 3). In the multivariate logistic regression model for period 2016–2019, all variables except 3<sup>rd</sup> and 4<sup>th</sup> birth order and medium maternal education, were significantly associated with seasonality when simultaneously entered in one model. The multivariate logistic regression model for period 2018–2019 shows similar results but, as the variable maternal employment status is considered, showing the highest odds ratio, the maternal age variable is not significant.

Table 4 shows sociodemographic factors importance rank according to each one of the alternative data mining techniques used for period 2018–2019: logistic regression model, Bayesian Networks, Radial Basis Neural Networks, CHAID decision tree and discriminant analysis. Among the eight sociodemographic factors considered, those related to maternal employment status, maternal job qualification and maternal education were consistently found to be the most relevant influencing birth seasonality, whereas maternal age and population size were found to be the less relevant influencing factor in most models.

## 4 | DISCUSSION

In this study, birth seasonality by sociodemographic factors in Spain in the period 2016–2019 was investigated. Research has shown that different birth seasonal patterns take place in different sociodemographic groups, nevertheless, sociodemographic factors and birth seasonality association has not been assessed in Southern Europe.

TABLE 3 Number of births, and indicators of the seasonal variation in births by socio-demographics characteristics

	No. of births	No. of births (%)	Coefficient of variation (%)	Ratio of peak versus lowest birth rate month	Odds ratios (confidence intervals) of being born in the peak birth rate trimester <sup>a</sup>		
					OR crude 2016–2019	OR adjusted <sup>b</sup> 2016–2019	OR adjusted <sup>c</sup> 2018–2019
<b>All births</b>	1 510 817	100%	3.2%	1.10			
<i>Maternal age group</i>							
<20	29 857	2%	3.5%	1.13	1.00	1.00	1.00
20–24	111 053	7%	5.0%	1.19	1.04 (1–1.08)**	1.06 (1.02–1.1)**	1.03 (0.98–1.09)
25–29	266 922	18%	4.3%	1.14	1.01 (0.98–1.05)	1.06 (1.03–1.1)**	1.03 (0.98–1.08)
30–34	508 767	34%	3.3%	1.13	0.97 (0.94–1.01)	1.07 (1.03–1.1)**	1.02 (0.97–1.08)
35+	594 218	39%	2.8%	1.09	0.98 (0.95–1.02)	1.1 (1.06–1.14)**	1.04 (0.99–1.1)
<i>Birth order</i>							
1st	734 960	49%	4.1%	1.12	1.00	1.00	1.00
2nd	573 577	38%	2.9%	1.13	0.92 (0.91–0.93)**	0.92 (0.91–0.93)**	0.92 (0.9–0.93)**
3rd	149 662	10%	4.6%	1.16	1.01 (1–1.03)	0.99 (0.97–1.01)	1 (0.98–1.02)
4th+	52 618	3%	5.7%	1.17	1.04 (1.01–1.06)**	0.99 (0.96–1.02)	1.02 (0.99–1.06)
<i>Maternal education</i>							
Low	489 995	32%	4.6%	1.16	1.00	1.00	1.00
Medium	531 179	35%	4.3%	1.11	0.97 (0.96–0.98)**	1 (0.99–1.01)	0.97 (0.95–0.99)**
High	489 643	32%	2.6%	1.10	0.9 (0.89–0.91)**	0.96 (0.94–0.97)**	0.94 (0.92–0.96)**
<i>Maternal marital status</i>							
Unmarried	712 639	47%	4.1%	1.13	1.00	1.00	1.00
Married	798 178	53%	3.2%	1.12	0.95 (0.94–0.95)**	0.97 (0.96–0.98)**	0.96 (0.95–0.98)**
<i>Population</i>							
<100 000	446 337	30%	3.7%	1.12	1.00	1.00	1.00
+100 000	1 064 480	70%	3.0%	1.10	0.97 (0.96–0.98)**	0.98 (0.97–0.99)**	0.98 (0.97–0.99)**
<i>Job qualification</i>							
Low	833 780	55%	4.6%	1.15	1.00	1.00	1.00
High	677 037	45%	2.6%	1.11	0.91 (0.9–0.92)**	0.94 (0.93–0.95)**	0.92 (0.9–0.94)**
<i>Maternal country of birth</i>							
Other	386 676	26%	5.1%	1.17	1.00	1.00	1.00
Spain	1 124 141	74%	2.8%	1.11	0.93 (0.92–0.94)**	0.96 (0.95–0.97)**	0.93 (0.91–0.94)**
<i>Maternal employment status<sup>d</sup></i>							
Other	259 914	36%	4.3%	1.18	1.00		1.00
Employed	461 965	64%	4.5%	1.14	1.07 (1.06–1.09)**		1.15 (1.13–1.17)**

<sup>a</sup>Only births in August to October and March to May were included in calculating the odds ratios (see Materials and Methods).

<sup>b</sup>Maternal age, birth order, maternal education, maternal marital status, population, job qualification, maternal country of birth (2016–2019).

<sup>c</sup>Maternal age, birth order, maternal education, maternal marital status, population, job qualification, maternal country of birth, employment status (2018–2019).

<sup>d</sup>The variable maternal employment status is only available for 2018–2019.

\*\*Significative 95%.

Although factors related to maternal labor status had only partially been considered in previous articles, in this study maternal employment factors (employment status,

job qualification and education) have been found to be the most relevant, among the sociodemographic factors, influencing birth seasonality in contrast with other



TABLE 4 Sociodemographic factors importance rank, 2018–2019

Nodes	Bayesian network		Radial basis neural network		CHAID tree		Discriminant analysis		
	Importance	Nodes	Importance	Nodes	Importance	Nodes	Importance	Nodes	
Job Qualification	0.213	Education	0.467	Job Qualification	0.291	Employment status	0.260	Employment status	0.250
Employment status	0.211	Job Qualification	0.272	Employment status	0.217	Job Qualification	0.244	Job Qualification	0.238
Parity	0.192	Employment status	0.124	Education	0.134	Country of birth	0.186	Education	0.140
Education	0.124	Marital status	0.067	Population size	0.116	Education	0.088	Country of birth	0.123
Marital status	0.092	Parity	0.040	Marital status	0.106	Age	0.074	Marital status	0.104
Country of birth	0.089	Population size	0.017	Country of birth	0.081	Parity	0.059	Parity	0.053
Population size	0.042	Country of birth	0.010	Age	0.032	Marital status	0.050	Population size	0.052
Age	0.037	Age	0.004	Parity	0.023	Population size	0.041	Age	0.041

demographic factors typically studied (maternal age, maternal country of birth, marital status, parity or city size). Our study is the first in which the ranking of the sociodemographic factors by importance has been assessed and therefore, results cannot be compared.

As in other countries, a seasonal pattern was found: the birth rate picked in August–October, whereas the three lowest months were March–May. However, the curve was found to be bimodal, with a secondary birth trough in November and December and a second birth spike in January, as occurs in several European countries (Régnier-Loilier & Divinagracia, 2010). We also found that the magnitude of seasonal variation of births was associated with maternal sociodemographic characteristics. The seasonal variation was more pronounced in mothers who were older, not married, pregnant with their fourth child or more, had lower education, lower job qualification, were employed, giving birth in a small town (<100 000) and were not born in Spain. By contrast, birth seasonality was weak in mothers who were younger, married, pregnant with their second child, had higher education, with higher job qualification, were giving birth in a big town (>100 000) and were born in Spain. The low-seasonality social group (younger mothers, married, pregnant with their second child, with higher education, not employed or with higher job qualification, giving birth in a big town and born in Spain) was more likely to give birth in the spring and less likely to give birth at the end of the year than the other group. When considering all the factors in the same model to explain high seasonality, all the characteristics except age were found to be significant. Among the eight sociodemographic factors considered, those related to maternal labor activity (employment status, job qualification and education) were found to be the most relevant influencing birth seasonality. Lower skilled employed mothers followed the overall seasonal pattern whereas high skilled employed mothers showed a flatter curve.

The results are unlikely to be due to random error. We used complete data for the whole population. The number of births in the analysis was large, the seasonal differences were clearly pronounced and showed consistency through the different sociodemographic characteristics. The results are also unlikely to be due to low quality data: the Vital Statistics in Spain constitute one of the most traditional statistical operations in the National Statistics Institute and births were recorded in 1863 for the first time and have been recorded from 1900 onwards in continuous way.

What is the impact of maternal sociodemographic characteristics and specifically maternal characteristics related to labor activity on seasonality of birth? Our results show two clear different behaviors: first,



unemployed or economically inactive women are more likely to conceive during the spring, since their birth peak is found in January–March. Second, employed or student women are more likely to conceive in early winter, since their birth peak is allocated in September. However, employed mothers' birth patterns are shaped according to their educational level and job qualification. Low-skilled women are more likely to conceive at the very end of the year, as they show a clear birth peak in September that has been linked in other studies to Christmas period and New Year's Day conceptions (Régnier-Loilier & Divinagracia, 2010). Instead, high-skilled women are more likely to conceive both at the very end of the year and in the summer, since in addition to the high peak in September they show higher birth rates during the spring. These results are notably consistent with the findings showing that sexual activity is strongly structured around holidays, weekends, and summer months and that elevated sexual activity is generally associated with leisure time and/or time off work (Symul et al., 2020). An explanation for these different behaviors is that unemployed mothers, economically inactive mothers and permanently disabled mothers are less affected by the seasonality of work and studies than employed and student mothers. Being less affected by the seasonality of work and studies calendar may translate into a different seasonality of both sexual intercourse (generally associated with leisure time) and fertility (since photoperiod, temperature, humidity, and availability of food can affect semen quality and ovulation rate), ultimately shaping birth seasonality. It seems that maternal employment status conditions the periods of holidays and leisure time becoming a good sociodemographic discriminator of the different birth seasonal patterns, above other sociodemographic characteristics such as age, marital status, parity, or country of birth. However, as stated in a recent study (Symul et al., 2020), holidays are unlikely to provide a complete explanation of birth seasonality, not being its primary driver. According to this study, birth seasonality is primarily driven by seasonal fertility, although increased sexual activity around holidays explains minor peaks in the birth curve. When considering what has already been described for Spain in an extensive analysis of birth seasonality over 60 years (Cancho-Candela et al., 2007), we find that a similar conclusion was reached: in the period 1940–2000 the appearance of conception maximums coincides with summer and December, but the authors suggest that annual vacations are insufficient to generate the rhythm found. Namely, birth seasonality is not alternatively but additionally explained by seasonal sexual activity. Although seasonal fertility may be considered the main driver, seasonal sexual activity is likely to have a non-negligible

impact on birth seasonality, which may be shaped by the working calendar in different degrees, depending on maternal labor status. Specifically for Spain, seasonal sexual activity has been related to the influence of religious calendar during which sexual intercourse was banned (Simó-Noguera et al., 2020). Also, Cancho-Candela et al. (2007) showed a secondary peak in conceptions in December visible for the period 1940–2000 and a peak in conceptions in summer that began to be visible in Spain from the 1960s, precisely when women began to enter the labor market, and that was fully visible in the 1980s. Then the seasonal pattern disappeared in Spain in the 1990–2000, although it was still perceived that the maximum number of conceptions occurred in December. Consistently with Cancho-Candela et al. (2007), the September birth peak (or December conception peak) is clearly maintained in the 2016–2019 period that has been analyzed in this study, whereas a secondary birth peak is visible for employed women from April to June, corresponding to conceptions in July–September. We might then hypothesize that when a majority of women wasn't economically active (1940–60), the main conception pattern, probably driven by seasonal fertility, was established in the spring, and that as women entered the labor market (from 1960 onwards), they were more conditioned by the work calendar, showing a pattern of higher conceptions around holidays. Then, due to a majority of women being conditioned by labor calendar, both patterns are compensated between them showing a flat curve (1990–2000).

Although holidays are unlikely to provide a complete explanation of seasonality, they have been associated with increased sexual activity in other studies (Russell et al., 1993). In England and Wales, the trends point consistently to an increase in sexual activity occurring at or around the Christmas period, and a longer but less pronounced subsidiary period of increased sexual activity coinciding with the summer vacation (Wellings et al., 1999). A persistent September local peak in births has been observed in northern populations (Lam & Miron, 1994) which conforms to long suspected seasonal conceptions in December (Lerchl et al., 1993). More recently it has been stated that conception dates vary mostly due to cultural factors, such as holidays (Wood et al., 2017).

On the other hand, Symul et al. (2020) found all countries considered in their study having elevated sexual activity on weekends and decreased sexual activity on weekdays and elevated sexual activity on holidays. More importantly, for all locations, the time between Christmas and New Year had the highest level of sexual activity. It was found that sexual activity is strongly structured around holidays, weekends, and, in some locations,

summer months. Compared to annual vacations that seem to be more spread along the year (Grigolon et al., 2014), Christmas vacations are widely generalized and focused on specific days. As weekends are uniformly distributed throughout the year and therefore may not be able to explain monthly seasonality, summer and primary Christmas holidays may be the periods with the ability to affect birth seasonality.

In any case, birth seasonality might be related to seasonality of intercourse, but really it is seasonality of non-contracepting intercourse that matters, as reliable contraception is widely used in Spain (Ruiz-Muñoz et al., 2011). Nevertheless it seems that the same conclusions may apply: women using contraception methods have been found to behave similarly in terms of sexual activity around holidays to those who do not use them (Symul et al., 2020); holidays are claimed to be associated with increased sexual activity and slackness in contraceptive use (Russell et al., 1993); and in England and Wales the evidence points to an increase in sexual activity and unsafe sex occurring at or around the Christmas period, and a longer but less pronounced subsidiary period of increased sexual activity and unsafe sex coinciding with the summer vacation (Wellings et al., 1999).

Moreover, we found that a change in the rhythm pattern has taken place in the last decades in Spain, moving from a birth rate pick in February–April in 1940–1960 to a lack of pattern during 1990–2000 (Cancho-Candela et al., 2007) to a birth rate pick in August–October during 2016–2019. As the new seasonal pattern seems to be driven by low-medium educated employed mothers and factors related to maternal labor activity were found to be the most relevant sociodemographic factors influencing birth seasonality, we might hypothesize that women's participation in labor force could be playing a major role in the seasonal change observed in Spain. During the last half century, the Spanish labor market has experienced important changes regarding women participation: women's activity rate has increased in Spain from 28% in 1977 to 53% in 2016–2019 according to Spanish Labor Force Survey. At the same time, fecundity index has varied from 2.8 children average per woman in the 1975 to 1.3 in 2016–2019 according to the Spanish National Statistics Institute, while the correlation of employment uncertainty with a substantial postponement of second births is well known (Adsera, 2011). Other developed societies have experienced similar changes. It has been argued that changes in labor market and family patterns in Sweden may be affecting childbearing decisions to suit both partner's labor market careers (Dahlberg & Andersson, 2018). In France, where a similar change in seasonal pattern has been found, it has been shown that different mother's occupations may lead to different seasonal curves, being significantly illustrative the case of

the primary school teachers (Régnier-Loilier & Wiles-Portier, 2010). It is likely that in contemporary advanced societies the effect of sociodemographic factors related to labor activity have a relevant influence in birth seasonality.

Additionally, no matter what the overall seasonal pattern was, high educated women, married and pregnant with their second child showed higher birth rates during the spring and a pattern of depressed birth rates in November and December also in Sweden (Dahlberg & Andersson, 2018), Czech Republic (Bobak & Gjonca, 2001), Mexico (Azcorra et al., 2017) and Iran (Khajavi et al., 2016). Also in France and Holland the dates of birth for second children appear to be planned often in the spring (Prioux, 1988). This seems to suggest that a higher need, willing or capacity to plan births in spring and to avoid the end of the year arise specifically in these sociodemographic groups of women. This explanation would not alternatively but additionally explain the differences among different sociodemographic groups. A general preference for spring is shown in the literature: for pregnancies planned between 1970 and 1993, it was reported that in Spain, Italy and Denmark, women preferred to give birth in spring (Basso et al., 1995). In France, a proportion of couples (around one in seven) attempt to schedule their child's birth, often aiming for spring (Régnier-Loilier & Wiles-Portier, 2010). But, are higher educated women more willing to give birth in spring and to avoid the end of the year? In United States more educated women are more likely to choose what is called “good” season births (2nd and 3rd quarter of the year) (Clarke et al., 2016). In Japan more than 1800 births per year are delayed by about 1 week in order to occur after the school cutoff date, by means of postponed caesarean sections, mostly by highly educated mothers and it has been proposed that parents who value potential long-term academic gains over the short-term gain of childcare cost savings do exploit birth timing as a means of early childhood investment (Shigeoka, 2015). The birth seasonality in Sweden among couples with normal fecundity are what it would be expected if couples actively plan their births according to the cut-off date for Swedish pupils' school entry (Dahlberg & Andersson, 2019). Are women with certain occupations more willing to plan their births to happen during the spring? In France and US different mother's occupational categories showed clear different seasonal patterns (Clarke et al., 2016; Régnier-Loilier & Wiles-Portier, 2010). Finally, the use of contraception varies with sociodemographic factors and is more common among more highly educated women and with children (Spinelli et al., 2000) and it has been argued that women with previous births are equipped with better understanding of their fecundity and therefore better able to

plan their next birth so that it does not occur at the end of the year (Dahlberg & Andersson, 2018).

Finally, certain sociodemographic factors associated with preterm births may be slightly shaping the overall seasonality. It is known that specific lower working conditions affect the risk of preterm birth (Saurel-Cubizolles et al., 2004) and in Spain it has been shown that maternal age  $\leq 19$  years, immigrant mothers, educational level  $\leq$  secondary studies, and women living in large cities are socio-demographic variables associated with preterm birth (Hidalgo-Lopezosa et al., 2019). Nevertheless, Spanish Vital Statistics estimates preterm births percentage around 6.6% in 2016–2019, with a surplus of observed preterm births around May–August, that do not modify the overall seasonal pattern, as the overall seasonal pattern remains similar to the original when not considering the preterm births and also when simulating the preterm births to take place at 40 weeks of gestational age.

This study finds that, when considering sociodemographic factors, birth seasonality is to a large extent related to maternal employment status. Employed and student mothers, usually more affected by seasonality of work and school calendar, show conception dates strongly structured around holidays (Christmas and summer months), whereas unemployed and economically inactive mothers show a completely different seasonal pattern with higher conception rates during the spring. Additionally, these different seasonal birth patterns may have to do with the need, willing or capacity to plan births that arise in different groups of women. Factors such as the occupation needs or value given to education may also be playing a role in pregnancy decisions.

The hierarchy of sociodemographic factors found reinforces the hypothesis that the observed change of seasonal pattern in Spain in the last decades, as in other European countries, may be to some extent driven by the progressive higher participation of women in labor market in contrast with other proposed explanations in former studies.

#### AUTHOR CONTRIBUTIONS

**Francisco Bolúmar:** Methodology (equal); writing – review and editing (equal). **César Pérez López:** Methodology (equal); review and editing (equal). **Adela Recio Alcaide:** Conceptualization (lead); Methodology (equal); writing – original draft (lead); formal analysis (lead); writing – review and editing (equal).

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#### CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

#### DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in INE Vital Statistics Microdata at [https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica\\_C&cid=1254736177007&menu=resultados&idp=1254735573002#](https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736177007&menu=resultados&idp=1254735573002#)

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APPENDIX

Figures A2–A7 show seasonal variation in births by maternal employment and educational status, 2018–2019.

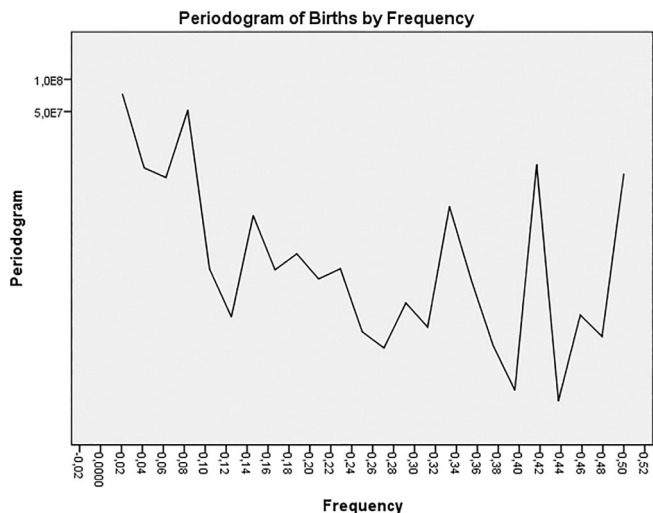


FIGURE A1 Periodogram of births by frequency, 2016–2019

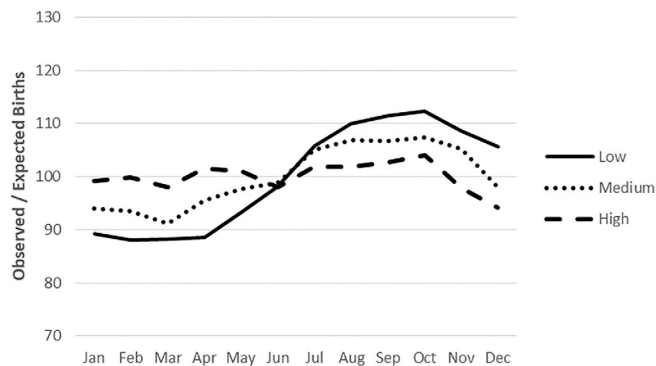


FIGURE A2 Employed mothers by educational level

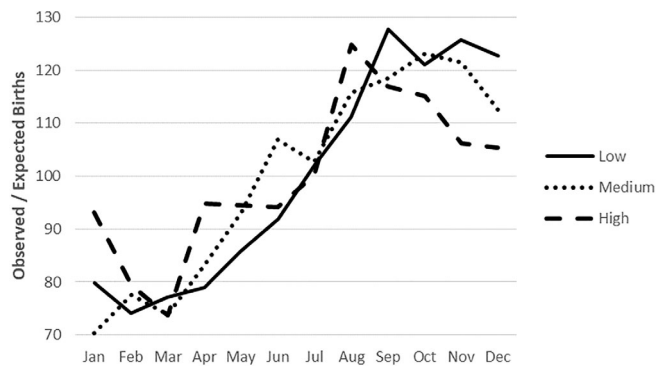


FIGURE A3 Student mothers by educational level

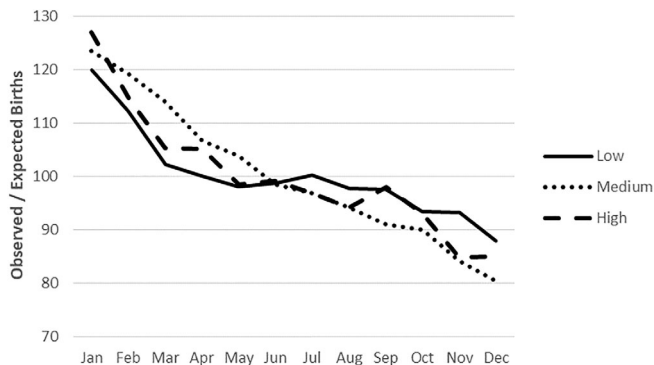


FIGURE A4 Unemployed mothers by educational level

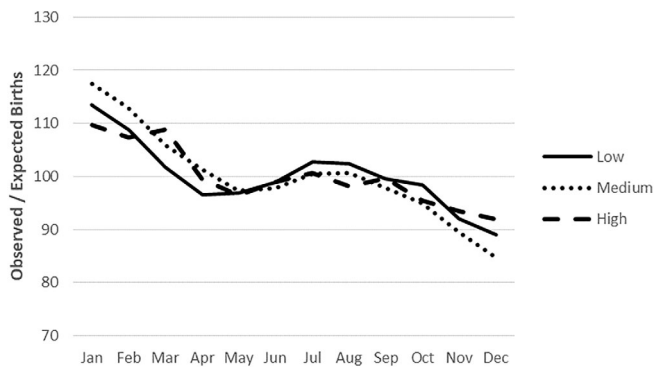


FIGURE A5 Economically inactive mothers by educational level

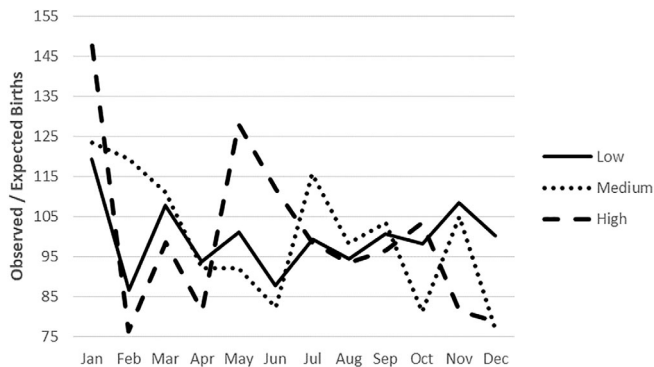


FIGURE A6 Permanently disabled mothers by educational level

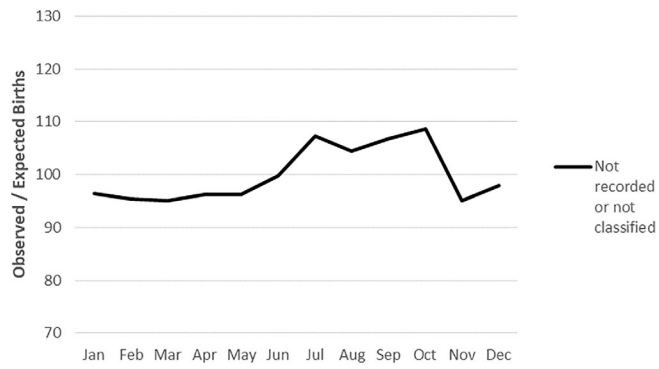


FIGURE A7 Not recorded or mothers who cannot be classified