DEMOGRAPHIC RESEARCH
A peer-reviewed, open-access journal of population sciences

DEMOGRAPHIC RESEARCH

VOLUME 49, ARTICLE 17, PAGES 465–478
PUBLISHED 5 SEPTEMBER 2023
https://www.demographic-research.org/Volumes/Vol49/17/
DOI: 10.4054/DemRes.2023.49.17

Descriptive Finding

Partial fertility recuperation in Spain two years after the onset of the COVID-19 pandemic

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Demographic Research: Volume 49, Article 17
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Abstract

BACKGROUND
Following the onset of the COVID-19 pandemic a host of countries saw drastic fertility declines, followed by a variety of fertility patterns. It remains unclear whether these initial baby busts have been recuperated, and, if so, whether the recuperation occurred homogenously across maternal age groups and parity categories.

OBJECTIVE
We assess period fertility recuperation as the cumulative difference between observed fertility trends and a predicted counterfactual trend simulating fertility patterns without the pandemic. We focus on Spain, the European country that suffered the most severe fertility decline during the pandemic.

METHODS
We use vital statistics on Spain and ARIMA models to forecast counterfactual trends in total, age-specific (15–24; 25–34; 35–49), and parity-specific (first vs. second+ births) fertility rates for the months when fertility could have been affected by the pandemic. We then calculate the cumulative residual between modeled/forecasted trends and observed fertility rates to estimate the fertility deficit and recuperation.

RESULTS
By December 2021, Spain had only seen a partial and heterogenous fertility recuperation, relative to expected trends. Births from women at the beginning and end of their reproductive ages and those transitioning to first child had not yet recuperated, whereas women in the middle of the fertility window and second or higher order births had fully recuperated.

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CONTRIBUTION
We assess period fertility recuperation as the cumulative difference in observed fertility trends compared to a predicted counterfactual trend simulating fertility without the pandemic, and show a lack of period fertility recuperation. If this translates into cohort fertility decline, there may be consequences for childlessness and population structure in Spain.

1. Introduction

As of mid-2023, COVID-19 has followed the path of previous pandemics. It has brought unprecedented distress to human populations and killed more than 6.5 million individuals across the globe. The pandemic has also accelerated demographic change, with research highlighting its impact on life expectancy (Aburto et al. 2021), migration (González-Leonardo and Spijker 2022), and fertility (Aassve et al. 2021; Arpino, Luppi, and Rosina 2021; Berrington et al. 2022; Cohen 2021; Cozzani et al. 2023; Nitsche et al. 2022; Sobotka et al. 2021, 2022). Several studies have documented the immediate fertility consequences of the pandemic, showing profound and sudden period fertility busts across (Aassve et al. 2021; Sobotka et al. 2021) and within (Arpino, Luppi, and Rosina 2021; Nitsche et al. 2022) countries such as the United Kingdom (Berrington et al. 2022) and Spain (Cozzani et al. 2023). To date, studies of fertility after the early busts in 2020 resulting from the onset of the COVID-19 pandemic have presented a varied picture. Some countries show a baby bump in 2021 (Bailey, Currie, and Schwandt 2022), and others first a bump and then another bust (Sobotka et al. 2022).

However, so far only a study from the United States (Bailey, Currie, and Schwandt 2022) has analyzed whether, for whom, and the extent to which these patterns have led to a recuperation of the lost births in period fertility. It is important to focus on recuperation. Failure to recover period fertility could translate into cohort fertility declines, exacerbating declining fertility rates and accelerating population aging with significant consequences for population structure, particularly in already-low and declining fertility settings.

In this article we study recuperation of period fertility declines in Spain by predicting a counterfactual trend of period fertility forecasted as if the pandemic had never happened. Spanish fertility saw the largest decline in Europe during the pandemic, with the total fertility rate (TFR) reaching an unprecedented low of 1.0 in December 2020, nine months after the onset of the COVID-19 pandemic. We forecast the counterfactual scenario using time series analyses and compute the cumulative residual from the predicted trend using actual observed fertility rates during the pandemic. Overall, we provide a comprehensive view of period fertility recuperation (or the lack thereof) in Spain relative to the expected trend across different maternal age groups (15–24, 25–34, 35–49) and parity categories (first vs. second+ births), while newly released data allows us to investigate a longer period than previous research and to consider subgroup fertility rates.

2. Data

We combined monthly age- and parity-specific birth counts from population birth certificates in Spain for the period January 2016 to December 2021 with population figures for the number of women in each age group between 15 and 49 years. Microdata on birth counts and population figures were provided by the Spanish Statistical Institute (INE). (See data availability statement and supplemental material for direct links to the data.) The study relies solely on secondary analyses of deidentified public data sources, and therefore we did not seek ethical approval. All code with link for data is available as supplementary material.

3. Method

From the individual data we calculated monthly age- and parity-specific fertility rates, as well as the Total Fertility Rate (TFR). Using maximum likelihood, we estimated seasonal time series ARIMA regressions of the monthly TFR for the period January 2016–September 2020. Once the models were stationary according to the augmented Dickey-Fuller test we inspected the residuals for any remaining statistically significant autocorrelation, as well as testing for normality (Shapiro-Wilk normality test) and independence of sequence (runs nonnormality) and performing a portmanteau test (Ljung-Box test). We then chose the model meeting the above criteria that had the smallest-small, sample-corrected Akaike Information Criteria value.

We fitted separate models for different age and parity groups. Based on the models, we then forecasted the expected TFR for the period October 2020–December 2021. To gauge the change in fertility behavior, we then obtained the monthly residuals between the observed and fitted/forecasted values and plotted the cumulative sum of the residual over the study period (January 2016–December 2021). All analysis was carried out using Stata 17.0 and R Project 4.3.0. Below we report the specification of each time series regression presented in the study.

TFR:
$$TFR_t = \mu + \theta_1 TFR_{t-1} + \theta_2 TFR_{t-12} + c + \epsilon_t \quad (1)$$

First Parity Fertility Rate:
$$FPFR_t = \mu + \theta_1 FPFR_{t-1} + \theta_2 FPFR_{t-12} + I(\text{March, 2020}) + c + \epsilon_t \quad (2)$$

Second+ Parity Fertility Rate:
$$SPFR_t = \mu + \theta_1 SPFR_{t-1} + \theta_2 SPFR_{t-12} + I(\text{April, 2020}) + c + \epsilon_t \quad (3)$$

Age-Specific Fertility Rate 15–24 years:
$$\Delta ASFR_t^{15-24} = \theta_1 \Delta ASFR_{t-1}^{15-24} + \theta_2 \Delta ASFR_{t-12}^{15-24} + \Delta\epsilon_t - \theta_3 \Delta\epsilon_{t-3} \quad (4)$$

Age-Specific Fertility Rate 25–34 years:
$$ASFR_t^{25-34} = \mu + \theta_1 ASFR_{t-1}^{25-34} + \theta_2 ASFR_{t-12}^{25-34} + c + \epsilon_t \quad (5)$$

Age-Specific Fertility Rate 35–49 years:
$$ASFR_t^{35-49} = \mu + \theta_2 ASFR_{t-12}^{35-49} + \epsilon_t \quad (6)$$

where μ is the intercept, θ_1 is the autoregressive term of order 1, θ_2 is the seasonal autoregressive term of order 1, θ_3 is the moving average term of order 3, Δ is the first difference indicator, c is the drift term, $I()$ is an important outlier indicator, and ϵ is the residual. The important outliers included in Equations 2 and 3 coincide with the start of the pandemic and were included to ensure good fit statistics for the time series models, which otherwise failed to pass tests for being stationary. Because all months studied prior to October 2020 only serve to inform the counterfactual forecast, we do not interpret the existence of the two outliers and further note that they are only present in the by-parity breakdown of fertility rates.

4. Results

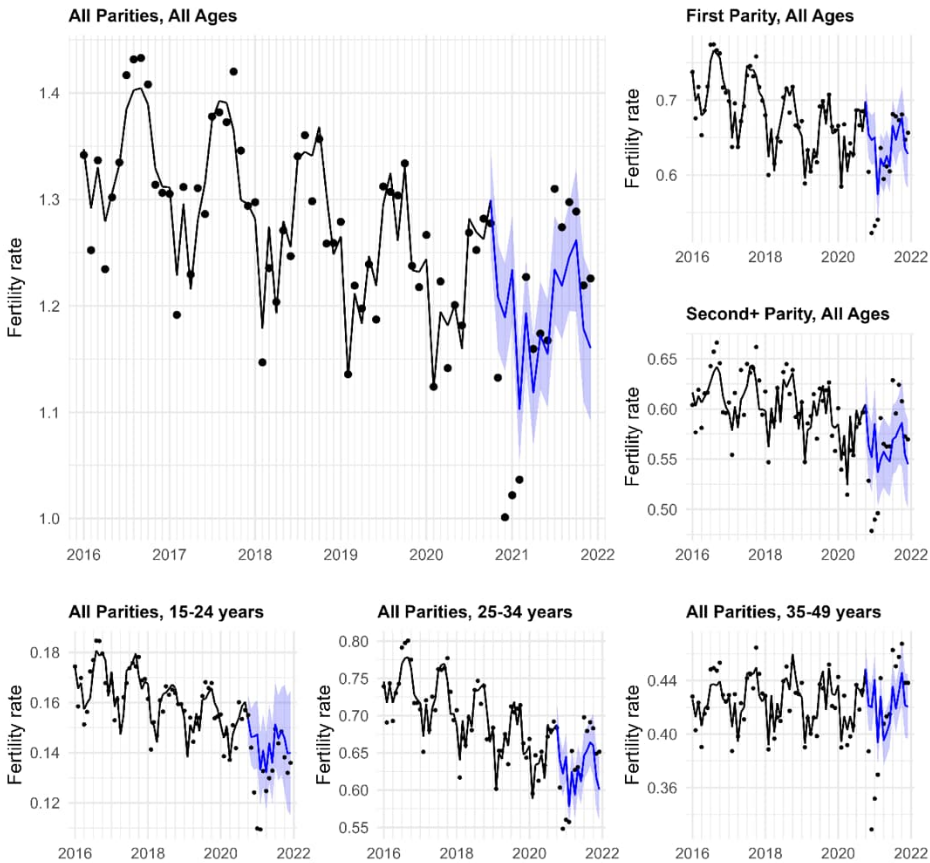
Using ARIMA time series analysis and publicly available Spanish birth records data, we modeled trends in monthly TFR and age- and parity-specific fertility rates for the period January 2016 to September 2020 [the last month where fertility appeared unaffected by the pandemic (Cozzani et al. 2023)], and forecasted the expected fertility rates for the pandemic period of October 2020 to December 2021. Table 1 reports the time series regression estimates for the models used for forecasting the counterfactual trend, as well as test and diagnostic statistics. All time series regressions are stationary and meet standard diagnostic criteria. Figure 1 displays the fertility rates for all births, by parity group (first vs. second or higher order), and by age group (15–24, 25–34, 35–49). Dots report observed fertility rates, the lines show the modeled fertility rates, and blue areas show the 95% confidence interval for the forecasted fertility rates.

Table 1: Results from ARIMA models on monthly Spanish TFR, and age- and parity-specific fertility rates for January 2016–September 2020 (T = 57), standard errors in parentheses

	All parities All ages	Parity 1 All ages	Parity 2+ All ages	All parities Age 15–24	All parities Age 25–34	All parities Age 35–49
Intercept	1.3582	0.7352	0.6259		0.7568	0.4237
	(0.0251)	(0.0276)	(0.0113)		(0.0134)	(0.0051)
AR(1)	0.2972	0.6382	0.2783	–0.4211	0.2075	
	(0.1261)	(0.1038)	(0.1381)	(0.1192)	(0.1340)	
MA(3)				–0.4730		
				(0.1285)		
Seasonal AR(1)	0.9134	0.9212	0.7760	0.8347	0.8963	0.8843
	(0.0342)	(0.0316)	(0.0711)	(0.0631)	(0.0406)	(0.0438)
Drift	–0.0025	–0.0015	–0.009		–0.0020	
	(0.0004)	(0.0004)	(0.003)		(0.0002)	
IO		0.0301[a]	–0.0511[b]			
		(0.0111)	(0.0171)			
Differenced(1)	No	No	No	Yes	No	No
Test and diagnostic statistics						
Log-likelihood	121.51	155.08	148.20	212.00	148.21	178.09
AICc	–231.85	–296.48	–282.73	–415.22	–258.25	–349.72
Shapiro-Wilk Normality	p = .454	p = .434	p = .661	p = .738	p = .604	p = .211
Runs nonnormality	p = .807	p = .408	p = .179	p = .807	p = .579	p = .118
Augmented Dickey-Fuller[c]	p < .001	p < .001	p < .001	p < .001	p < .001	p < .001
Ljung-Box[d]	p = .224	p = .560	p = .085	p = .073[e]	p = .215	p = .537

Note: [a] March, 2020. [b] April, 2020. [c] Alternative hypothesis: Stationary; Lag order = 3. [d] Lags = 3 (Hassani and Yeganegi 2020). [e] Lags = 5.
Source: Own calculation based on data from INE.

Figure 1: Monthly observed, modeled, and forecasted fertility rates, January 2016–December 2021



Note: Dots represent actual rates, black line represents modeled rates using ARIMA models, and blue ribbons represent the 95% confidence interval of the forecast. For ARIMA model specifications, see *Methods*.
Source: Own calculation based on data from INE.

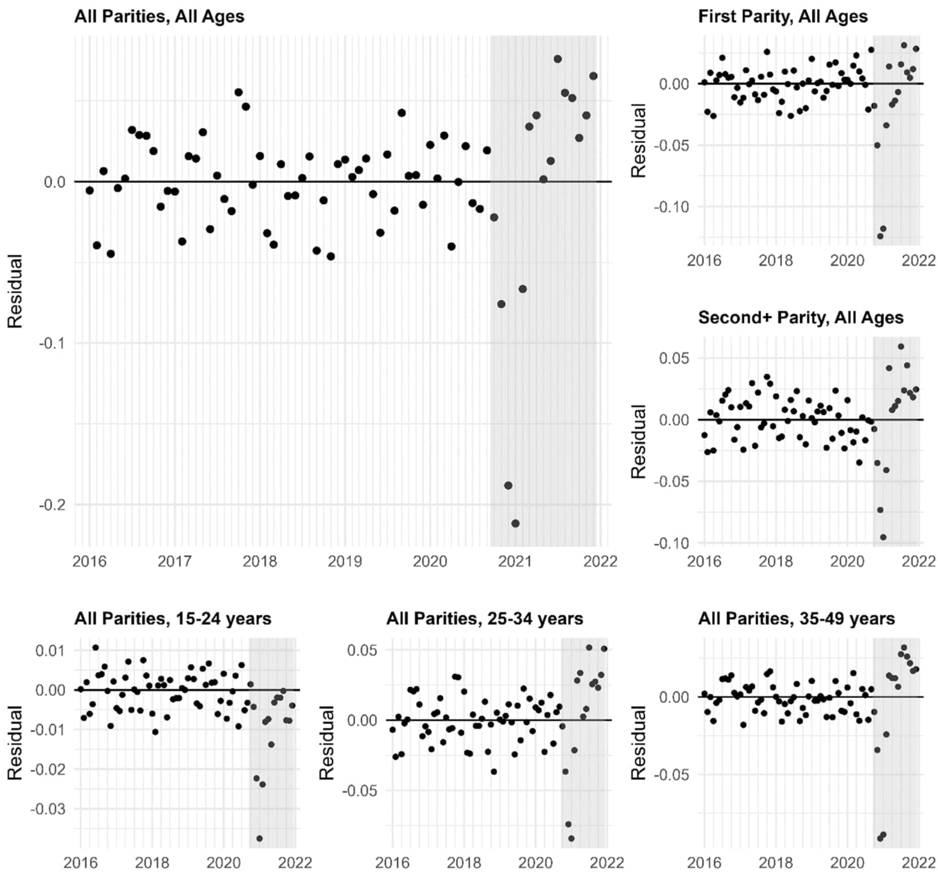
Throughout the study period, fertility was declining in Spain, with the decline consistent across parity categories and for all age groups except women aged 35–49. Overall, we observe a sharp decline in actual fertility rates between December 2020 and February 2021, with the TFR reaching the unprecedented low of about 1.0 in December

2020. During spring 2021 (March–June) the TFR returned to expected values, laying closer to the line and within the forecasted range. During summer 2021 the TFR increased above forecasted levels, suggesting a possible recuperation of previously foregone births relative to the expected trend. November and December 2021 showed expected values. Looking at different age and parity groups, the fertility rates followed a similar pattern, with a profound dip between December 2020 and February 2021, followed by higher-than-expected fertility rates in summer 2021. However, there are exceptions. First parity births and births to mothers at the beginning and the end of their reproductive lives do not display a summer rebound, suggesting that these groups may not have recuperated the pandemic fertility decline.

To demonstrate the extent of the recuperation (or lack thereof) we turn to Figures 2 and 3, where we display the time series residuals by month (Figure 2) and cumulated over the study period 2016–2020 (Figure 3). As seen in Figure 2, the model residuals are well distributed across zero for the period modeled directly (January 2016–September 2020), and then show large changes for the following period (October 2020–December 2021). There are also some indications of recuperation relative to trend for all births, second or higher parity births, and women older than 25.

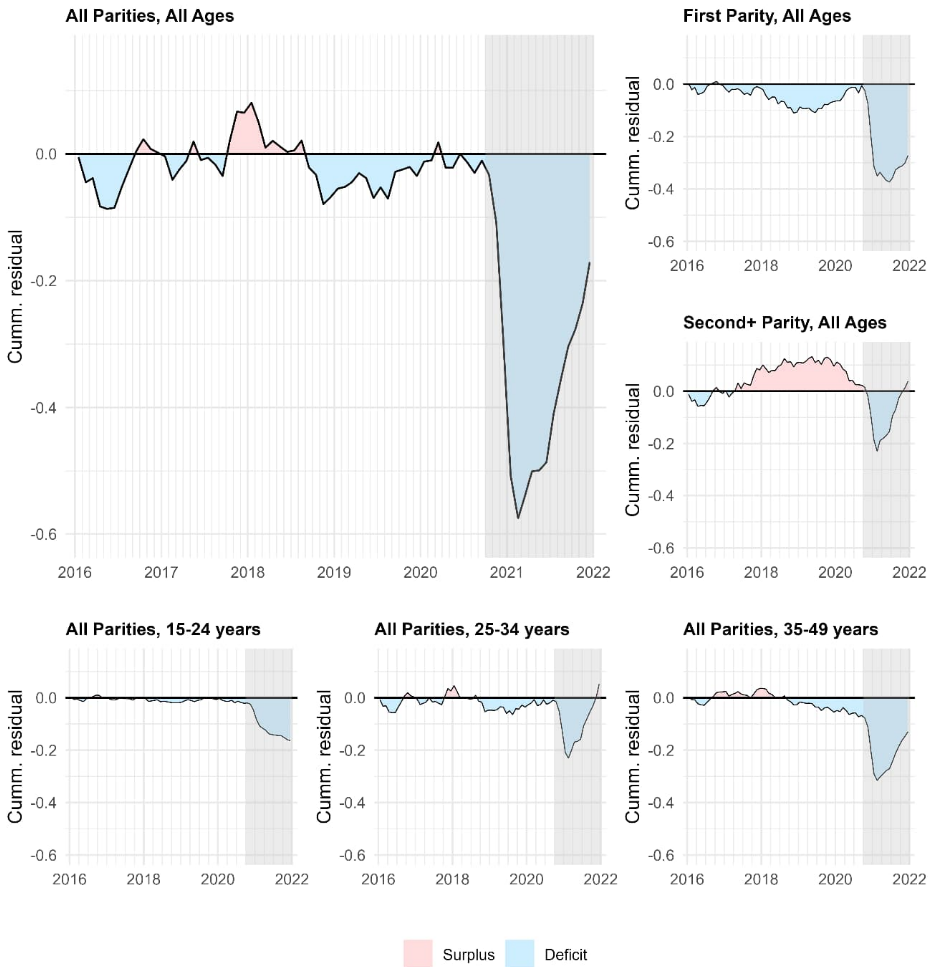
To gauge more clearly the extent of the recuperation, in Figure 3 we display the cumulative residual. Cumulated residuals below zero (blue area) signal a deficit of births relative to the model prediction. Cumulative residuals above the zero line (red area) indicate a surplus of births relative to the model prediction. By December 2021 the TFR in Spain had only partially recuperated relative to the expected trend of the fertility decline that followed the onset of the pandemic. Second or higher order parities and women aged 25–34 had fully recuperated, whereas first births and mothers at the beginning and the end of their reproductive lives had still not recuperated, although women aged 35–49 trended toward recuperation.

Figure 2: Time series residuals for all parities and ages, and by parity and age group



Source: Own calculation based on data from INE.
Note: The grey boxes indicate the period when pandemic-induced shocks to conceptions could have influenced fertility rates. For ARIMA model specifications, see *Methods.*

Figure 3: Cumulative time series residuals for all parities and ages, and by parity and age group



Source: Own calculation based on data from INE.
Note: Blue areas indicate fertility rates below modeled/forecasted, red areas indicate fertility rates above modeled/forecasted. The grey boxes indicate the period when pandemic-induced shocks to conceptions could have influenced fertility rates.
For ARIMA model specifications, see *Methods.*

Finally, we also quantify the extent of the recuperation. To this end we compute:

$$\%Recuperation_{Dec_{2021}} = 100\% * \left(1 - \frac{cr_{Dec_{2021}} - cr_{Sep_{2020}}}{\min(cr_{Oct_{2020}}, cr_{Nov_{2020}}, \dots, cr_{Dec_{2021}}) - cr_{Sep_{2020}}}\right) \quad (7)$$

where cr_t is the cumulative residual at a given month *t*. We compute the difference between the cumulative residual in the final observation period, December 2021 ($cr_{Dec_{2021}}$), and the value of the last pre-forecast period ($cr_{Sep_{2020}}$), divided by the difference between the lowest value of the cumulative residual across the forecasted period [$\min(cr_{Oct_{2020}}, cr_{Nov_{2020}}, \dots, cr_{Dec_{2021}})$] and the value for the last pre-forecast period ($cr_{Sep_{2020}}$). That is, we estimate the share of recuperation as the overall difference in cumulative residuals for the forecasted period (September 2020–December 2021), divided by the lowest value of the cumulative residual reached after September 2020 relative to the same month (September 2020).

Although these values include some noise due to the random-walk nature of residuals in time series models, we believe it provides a reasonable estimate of the extent of the recuperation, which we present in Table 2. Overall, at the end of December 2021, Spain had recuperated 72% of births relative to the expected trend, with large heterogeneity across parity and women's age.

Table 2: Percentage of pandemic fertility decline recuperated at December 31st, 2021, compared to September 2020

	All parities All ages	Parity 1 All ages	Parity 2+ All ages	All parities Age 15–24	All parities Age 25–34	All parities Age 35–49
Percentage recuperated	72%	28%	106%	0%	128%	75%

Note: Percentages are estimated as defined in Equation (7).

5. Discussion

In this descriptive finding, we propose a novel assessment of period fertility recuperation in Spain as of December 2021. We find evidence of only a partial recuperation relative to the expected trend, with a fertility recuperation only among second or higher order births and women aged 25–34. Our findings also highlight two important patterns of missed period fertility recuperation. First, in the wake of the pandemic, births among young women (<25) have not recuperated any of the decline and in fact still trend towards an increasing deficit. A possible explanation may be that this group of women is more likely to have experienced the worst economic consequences of the pandemic, as they were more likely to have been in more vulnerable positions in the labor market when the pandemic struck and this uncertainty may have further delayed their fertility plans. Another explanation may be that they were more likely to see a delay in union formation, thus shifting their reproductive schedule. Whether this reflects a tempo effect or will ultimately translate into lower cohort fertility rates may depend on the economic consequences of the pandemic and the future prospects of those who were young during the pandemic. Second, the only-partial fertility rate recuperations among older and first parity births may suggest that there has not been a recuperation of medically assisted reproduction (MAR) conceptions after the pandemic, as these are the groups most likely to use these technologies (Goisis et al. 2020). This interpretation is supported by Spain completely pausing MAR treatment during the first wave of the pandemic (Requena et al. 2020) while being one of the countries with the largest share of MAR newborns in the world (about 9%) (Goisis et al. 2023; Wyns et al. 2022). Access to reproductive healthcare and technologies may thus be crucial to counteract the pandemic's negative consequences for fertility. Further longer-term studies are required to understand whether the pandemic resulted in tempo or quantum effects on fertility for cohorts who were young and thus more economically fragile and for women who were approaching biological deadlines to fertility when the pandemic hit. The latter group was particularly vulnerable due to the closure of the window of opportunity for being able to conceive.

Finally, results from Spain diverge from those of other countries. Spain never saw a real increase in period fertility after the COVID-19 pandemic, as opposed to the persistent boom in the United States (Bailey, Currie, and Schwandt 2022) and the fluctuation in other EU countries (Sobotka et al. 2022). This may be due to three specificities of the Spanish context: Spain already had one of the lowest fertility levels in the world, it has a large share of precarious young individuals already postponing their fertility, and it is heavily MAR-dependent for fertility and it may have been difficult to recuperate all the missed cycles due to the pandemic. Future studies should directly test the role of economic uncertainty and missed MAR cycles in accounting for period fertility fluctuation after the COVID-19 pandemic.

6. Data availability statement

Microdata on birth counts are provided by the Spanish Statistical Institute (INE, www.ine.es) at https://www.ine.es/prodyser/microdatos.htm, and population figures can be retrieved at https://ine.es/jaxiT3/Tabla.htm?t=31304. All relevant documentation available from the INE website. All code is available as supplemental material.

7. Acknowledgments

This publication was produced with co-funding from the European Union – Next Generation EU, in the context of The National Recovery and Resilience Plan, Investment Partenariato Esteso PE8 "Conseguenze e sfide dell'invecchiamento", Project Age-It (Ageing Well in an Ageing Society, PE8-B83C22004800006), the ROCKWOOL Foundation (1227), and the Swedish Research Council for Health, Working Life and Welfare (2016-07099).

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