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Descriptive Finding

Changes in birth seasonality in Spain: Data from 1863–1870 and 1900–2021

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Descriptive Finding

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Abstract

BACKGROUND
Changes in birth seasonality patterns have been documented in several countries, whether long-lasting or temporary. In Spain, a decline in and absence of birth seasonality was reported in 1941–2000. This study extends the analysis to the full period of available monthly data, exploring changes in birth seasonality in Spain, its connection to social/health phenomena, and its related effects.

METHODS
We analyzed the two available monthly data periods: 1863–1870 and 1900–2021 (n = 73,338,010 births). Fourier spectral analysis and Cosinor analysis were performed to study changes in the overall seasonal pattern. The Chow structural change test analyzed punctual variations. Box-Jenkins time series methodology was applied to estimate the impact of related events on the number of live births.

RESULTS
The overall monthly pattern changes, shifting the maximum of births from February in the 19th century to September in the 21st century, experiencing a loss of amplitude. Three structural change points were found in the monthly series of observed/expected births, in 1919, 1940, and 2020, corresponding to the influenza pandemic, the end of the Spanish Civil War, and the Covid-19 lockdown, with temporary impacts on live births of –8.1%, 38.8%, and –16.4%, respectively.

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CONCLUSION
The seasonal pattern in Spain has changed substantially in shape and amplitude. While gradual changes appear to be associated with socioeconomic change, there is a clear connection between temporary changes and isolated social/health phenomena.

CONTRIBUTION
We study both gradual and temporary changes in birth seasonality, covering the entire period of data available in Spain, and quantify the effects of related isolated events.

1. Introduction

Birth seasonality has been documented in all human populations where it has been studied (Lam and Miron 1994). Possible explanations include environmental, biological, and sociocultural factors (Lam and Miron 1996; Bobak and Gjonca 2001; Dahlberg and Andersson 2018; Symul et al. 2020).

Changes in seasonality have also been documented in various countries. In 1975, several European countries showed a seasonal pattern of more births in the spring, while in 2005 births peaked in the summer (Régnier-Loilier and Divinagracia 2010). The reason for the changes in seasonal pattern is still unclear; proposed explanations include access to birth control, changes in the labor market, and the declining importance of religious belief (Cancho-Candela, Andrés-de Llano, and Ardura-Fernandez 2007; Dahlberg and Andersson 2018; Recio Alcaide, Pérez López, and Bolúmar 2022).

Along with overall long-lasting changes, some significant, isolated phenomena have been found to temporarily affect seasonal patterns and their intensity, mainly heat waves (Régnier-Loilier and Divinagracia 2010), pandemics (Chandra et al. 2018), and wars (Cypryjański 2019).

In Spain, a decline in and absence of birth seasonality was documented in 1941–2000. The seasonal pattern moved from a birth peak in spring during 1941–1960 to an absence of seasonality during 1991–2000 (Cancho-Candela, Andrés-de Llano, and Ardura-Fernandez 2007). It was observed that the effect of religious belief on birth seasonality disappeared with the advent of democracy and access to contraception (Simó-Noguera, Lledó, and Pavía 2020).

This study analyzes, for the first time, data on all available monthly births in Spain in order to examine the complete times series, describe both permanent and temporary changes in birth seasonality, and analyze their relationship to social/health events.

2. Methods

A monthly time series composed of 73,338,010 live births in Spain was analyzed in two periods: 1863–1870 and 1900–2021. A review of birth statistics from the Spanish National Institute of Statistics showed that 1863–1870 was only period in the 19th century when monthly information was registered. Birth statistics provide an exhaustive record of all births occurring in Spain. Live birth statistics compiled up until 1975 did not include infants who died within the first 24 hours. However, this does not noticeably alter the global figures. Since 1975 the definition of live birth has been that used in demography (INE 2013).

The monthly time series was analyzed as follows. First, absolute numbers of monthly live births were visually inspected. Second, the existence of a seasonal pattern that regularly repeats each year was confirmed with Fourier spectral analysis' periodogram. Third, a monthly series of the observed/expected number of births was built, correcting for the different numbers of days by month. Fourth, to account for changes in the overall rhythm pattern, the monthly number of live births was normalized by adjusting it to months of 30 days, and the deviation of the normalized series with respect to the 12-month Mobile Average (DMA) was submitted to rhythmometric analysis based on the least squares method by cosinor analysis (Refinetti, Cornélissen, and Halberg 2007; Cornelissen 2014). The cosinoidal curve of three harmonics (12, 6, and 4 months) was estimated by decade, allowing the estimation of two parameters in each decade: the amplitude, which represents half the difference between the maximum and the minimum of the curve, and the acrophase, which indicates the time of year when the maximum value is produced. Fifth, to provide statistical evidence of punctual abrupt variations and detect possible structural changes in the series of observed/expected live births, the Recursive Residuals Method (RRM) was applied together with the Chow structural change test, which analyzes the structural stability of the model at the points indicated by RRM, allowing confirmation of the importance of punctual changes that may be linked to major historical events. Sixth, to quantify the effect of these major historical events in terms of live births, econometric analysis and prediction was made following Box–Jenkins methodology for time series analysis (Pérez López 2011). Valid ARIMA models were identified for periods prior to the major historical events and a prediction of the number of births during the events was obtained based on the identified models. The comparison between observed and predicted number of births provided an estimation of the events' effects.

The RRM and Chow structural change test was performed using EViews 10. Fourier spectral analysis, cosinor analysis, and series modelling and prediction was performed using IBM SPSS Statistics 22.

3. Results

Monthly live births (Figure 1) during 1863–1870 show similar patterns in terms of level and amplitude to the first decades of the 20th century. In 1919, following the 1918 influenza pandemic and World War I, and from 1936 until early 1950s, coinciding with the Spanish Civil War (1936–1939) and the beginning of the Franco dictatorship (1939–1975), the series presents abrupt monthly movements. The amplitude of the monthly variation decreases along the whole series.

Fourier spectral analysis confirmed the existence of seasonality, with the second peak of the periodogram placed at 0.083 (1/12), revealing a periodicity of 12 months.

The monthly series of observed/expected live births (Figure 2) showed a structural decrease in the amplitude from 1940 onwards, when the Spanish Civil War ended. Several anomalies are observed: significantly higher/lower values coincide with important political or health events. The highest peak of observed/expected live births is found in March 1940, corresponding to a higher rate of conception in June 1939, probably due to the end of the Spanish Civil War in April of that year. The lowest observed/expected values are found in July 1919, corresponding to a lower rate of conception in November 1918 when the highest mortality rates of the 1918 influenza pandemic occurred in Spain (Chowell et al. 2014), and in December 2020, corresponding to a lower conception rate in March 2020 during the strongest Covid-19 pandemic wave (Redondo-Bravo et al. 2020). Other remarkable values were in January 1946, when a high value coincides with the end of World War II several months before; November 1951, when a low value corresponds with fewer conceptions in the previous January and February when mortality series show an excess of deaths caused by the 1951 influenza epidemic (Viboud et al. 2006a, 2006b; Blanes 2007); August 1958, whose lower value corresponds to a lower conception rate during the beginning of the 1957–1958 European influenza pandemic (Kuszewski and Brydak 2000); and December 1978, where higher and lower values coincide with the beginning of democracy in Spain.

Harmonic model estimation, DMA, and observed/expected live births for 1863–1870 and 1900–2019 decades are depicted in Figure 3. Cosinor analysis confirmed the decrease in amplitude, with values above 12 until 1940 falling to lows of 1.5 in the 1990s, and revealed a bimodal monthly distribution of births that has changed substantially between the 1860s and the present, with the acrophase shifting from February in 1863–1870 to September in 2010–2019.

Figure 1: Annual (1863–1870 and 1878–2020) and monthly (Jan 1863 – Dec 1870 and Jan 1900 – Dec 2021) live births in Spain

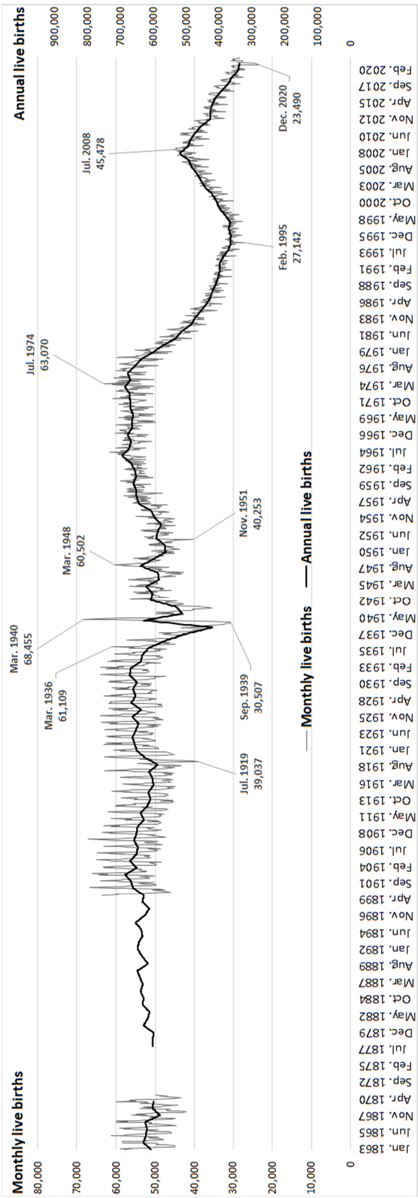


Figure 2: Observed/Expected number of live births by month (Jan 1863 – Dec 1870 and Jan 1900 – Dec 2021) in Spain

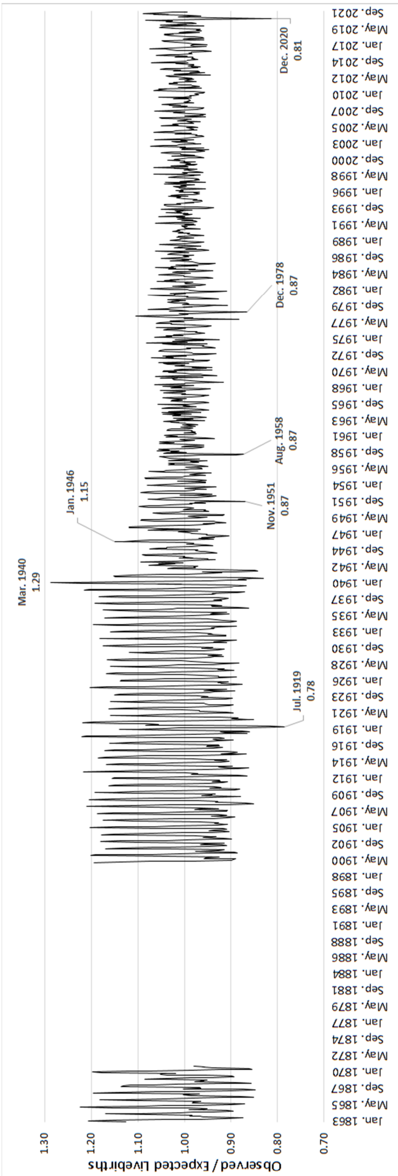
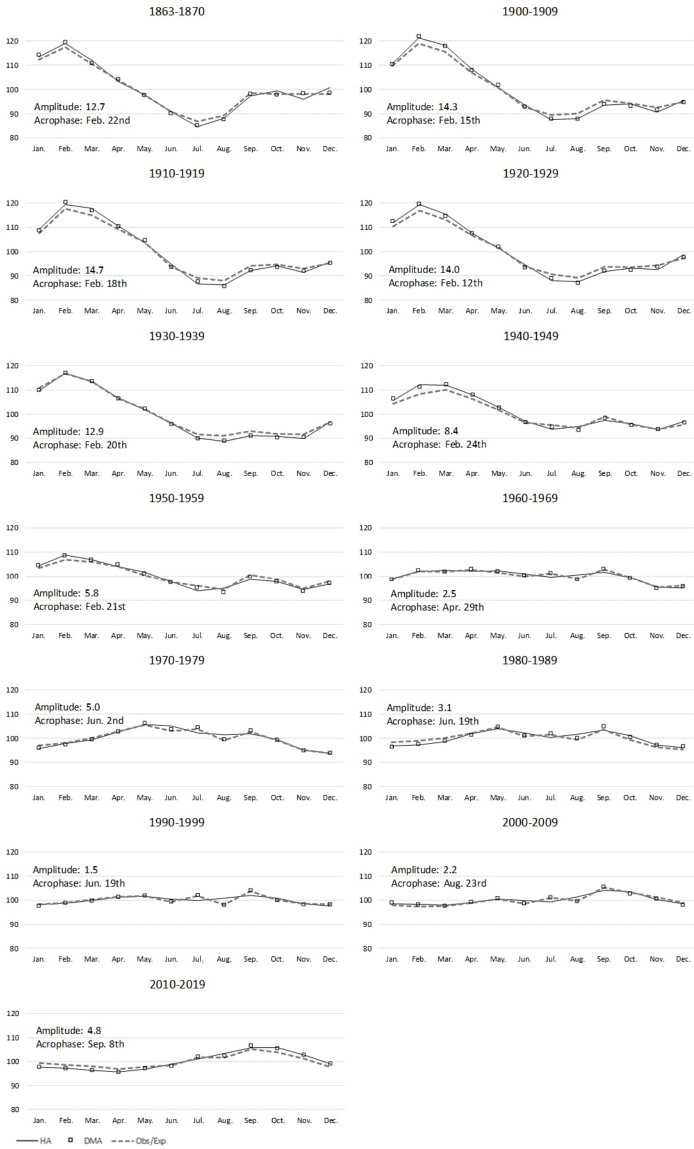
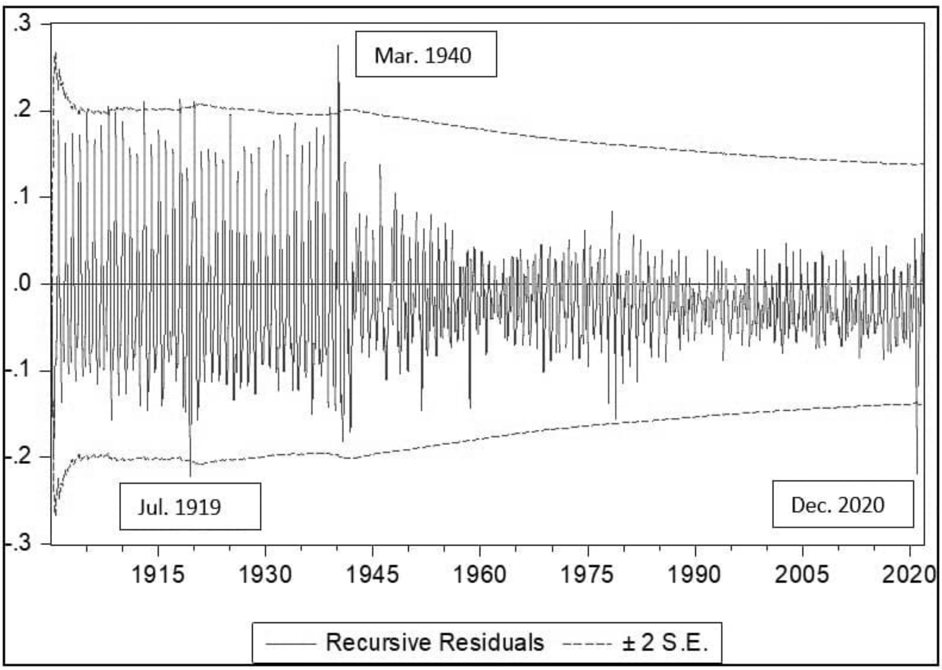


Figure 3: Harmonic model estimation (HA), average DMA, and observed/expected (%) live births by decade (1863–1870 and 1900–2019) in Spain



RRM, applied to detect possible structural changes in the series of observed/expected live births (Figure 4), suggests structural changes in July 1919, March 1940, and December 2020, as only these 3 points emerge clearly from the confidence bands. The structural stability of the model was tested at these three possible points using the Chow structural change test. The Chow test rejects the null hypothesis (no breaks at the specified breakpoints) for the three dates (p-values of 0.000, 0.000, and 0.0172 respectively), suggesting that the most important changes in seasonality took place in July 1919, March 1940, and December 2020, corresponding to events nine months earlier: the influenza virus pandemic, the end of the Spanish Civil War, and the Covid-19 pandemic, respectively. The period 1863–1870 was also tested but no structural changes were found.

Figure 4: Recursive residuals method applied to the 1900–2021 observed/expected series of live births



Finally, to quantify the effect in terms of the live births caused by these three events, Box-Jenkins methodology was used to identify three valid models for the prior periods (January 1914–April1919, January 1935–December 1939, and January 2015–August

2020, respectively) and the identified models were used to predict the number of births during the events. The identified valid models were ARIMA(1,0,0)(0,1,1)$_{12}$, ARIMA(0,1,0)(0,1,0)$_{12}$, and ARIMA(1,0,0)(1,1,0)$_{12}$, respectively. Table 1 shows observed and predicted live births during the events and surrounding months. Regarding the 1918 influenza pandemic, in July 1919 there was an 8.1% drop in expected live births, corresponding to a lower conception rate in November 1918 when the highest mortality rates of the 1918 influenza pandemic occurred in Spain (Chowell et al. 2014). Two months later, an evident excess of live births could be explained by the end of World War I in November 1918 and the end of the worst influenza wave. Regarding the end of the Spanish Civil War, an 38.8% excess of live births occurred in January 1940, corresponding to a higher conception rate during April 1939 when the war ended. The excess continued and grew over the following months. Regarding the Covid-19 pandemic, there was a 16.4% drop in expected live births in December 2020, corresponding to a lower conception rate in March 2020 when the first Covid-19 wave and lockdown occurred in Spain.

Table 1: Effect estimation, in monthly live birth series, of the 1918 influenza pandemic, end of the Spanish Civil War, and Covid-19 pandemic (probable month of conception shown in brackets)

Birth month	Observed live births (A)	Predicted live births (B)	Observed/Expected (A–B)	Effect (A–B)/B
Estimation of influenza pandemic effect on birth rates				
Mar 1919 (Jul 1918)	54,615	56,993	–2,378	–4.2%
Apr 1919 (Aug 1918)	50,084	50,485	–401	–0.8%
May 1919 (Sep 1918)	50,293	49,004	1,289	2.6%
Jun 1919 (Oct 1918)	41,632	43,094	–1,462	–3.4%
Jul 1919 (Nov 1918)	39,037	42,497	–3,460	–8.1%
Aug 1919 (Dec 1918)	40,649	41,520	–871	–2.1%
Sep 1919 (Jan 1919)	48,477	42,497	5,980	14.1%
Oct 1919 (Feb 1919)	53,915	44,558	9,357	21.0%
Nov 1919 (Mar 1919)	50,810	41,453	9,357	22.6%
Dec 1919 (Apr 1919)	53,955	44,026	9,929	22.6%
Estimation of effect of Spanish Civil War ending on birth rates				
Oct 1939 (Jan 1939)	30,871	30,930	–59	–0.2%
Nov 1939 (Feb 1939)	31,536	31,804	–268	–0.8%
Dec 1939 (Mar 1939)	37,699	35,413	2,286	6.5%
Jan 1940 (Apr 1939)	53,486	38,530	14,956	38.8%
Feb 1940 (May 1939)	60,885	33,864	27,021	79.8%
Mar 1940 (Jun 1939)	68,455	34,961	33,494	95.8%
Apr 1940 (Jul 1939)	63,725	30,182	33,543	111.1%
May 1940 (Aug 1939)	58,756	30,435	28,321	93.1%
Jun 1940 (Sep 1939)	48,488	27,161	21,327	78.5%
Jul 1940 (Oct 1939)	47,984	26,621	21,363	80.2%

Table 1: (Continued)

Birth month	Observed live births (A)	Predicted live births (B)	Observed/Expected (A–B)	Effect (A–B)/B
Estimation of Covid-19 pandemic effect on birth rates				
Sep 2020 (Dec 2019)	30,318	29,287	1,031	3.5%
Oct 2020 (Jan 2020)	30,296	30,619	–323	–1.1%
Nov 2020 (Feb 2020)	26,765	28,327	–1,562	–5.5%
Dec 2020 (Mar 2020)	23,490	28,095	–4,605	–16.4%
Jan 2021 (Apr 2020)	23,900	28,860	–4,960	–17.2%
Feb 2021 (May 2020)	24,403	25,349	–946	–3.7%
Mar 2021 (Jun 2020)	29,009	27,574	1,435	5.2%
Apr 2021 (Jul 2020)	27,298	26,195	1,103	4.2%
May 2021 (Aug 2020)	27,603	27,299	304	1.1%
Jun 2021 (Sep 2020)	27,519	26,602	917	3.4%

4. Discussion

This study considers, for the first time, all monthly birth data available in Spain, and extends the findings of previous research (covering 1941–2000, by Cancho-Candela, Andrés-de Llano, and Ardura-Fernandez 2007) by examining birth seasonality in three additional periods (1863–1870, 1900–1940, and 2001–2021). We observed a change in the rhythm trend, slowly moving from a birth peak in January–May during 1863–1950, to a transitional lack of pattern during 1990–2000, to a pattern marked by more births in July–November during 2000–2019. Thus, this study shows that the seasonal pattern observed during the first half of the 20th century in Spain was already present in the 1860s, remained stable for at least a century, and then shifted. Furthermore, we found a remarkable decrease in the size of seasonal variation from 1940 onwards. We observed some temporary alterations in seasonality throughout the entire series, all coinciding with important political or health-related events, the 1918–1819 influenza pandemic, the end of the Spanish Civil War, and the Covid-19 pandemic being the events that most significantly affected live births.

This study confirms that the decline in and absence of birth seasonality found in 1941–2000 in Spain (Cancho-Candela, Andrés-de Llano, and Ardura-Fernandez 2007) preceded a change in the birth rhythm pattern, consistent with that observed in other European countries (Lerchl, Simoni, and Nieschlag 1993; Régnier-Loilier and Divinagracia 2010; Ruiu and Breschi 2017; Cypryjański 2019). But what is the explanation for these changes in the overall seasonal pattern and its amplitude? Research has proposed several determinants: the availability of contraception (Lerchl, Simoni, and Nieschlag 1993; Cypryjański 2019; Simó-Noguera, Lledó, and Pavía 2020); a decline in the importance of being married for conceiving (Régnier-Loilier and Divinagracia 2010); and workplaces that are increasingly protected from photoperiodic and temperature influences, possibly leading to a 'deseasonalisation' of human reproduction and thus explaining the observed loss of amplitude (Lerchl, Simoni, and Nieschlag 1993). Furthermore, sociodemographic factors related to employment status have been found to influence most birth seasonality (Recio Alcaide, Pérez López, and Bolúmar 2022), suggesting that incorporation of women into the labor market and the transformation of economic activity may play an important role. Another proposed factor is the shift from agriculture to industry (Ruiu and Breschi 2020), which might apply to Spain: in 1900 the agricultural labor force was 67%, in 1950 it was 49%, but in the 1990s it was less than 10% (Alcaide 1976; Balboa, Delgado, and Cidad 1994). However, Spain is divided into 17 regions with very different climates and economic structures. To account for these differences, part of the analysis was replicated for all of the regions. We observed that the shift of peak births from spring to fall occurred in all regions, but it occurred earlier in the south-eastern regions and Canary Islands.

This may be explained by the fact that the south-eastern regions and Canary Islands are particularly influenced by tourism where labor activity is especially intense in the summer months, causing a lower propensity to conceive in summer than in the north-western regions. Additionally, high temperatures, characteristic of Spanish south-eastern regions, have been found to be correlated with a decline in birth rates 8–10 months later (Barreca, Deschenes, and Guldi 2018), which might contribute to explaining regional differences. Furthermore, the fact that children are more likely to be born in a parent's birth month (Recio Alcaide et al. 2023) contributes to explaining the stability of the seasonal pattern and its slowness to change.

Regarding the link between temporary alterations in seasonality and significant social/health events found in this study, similar evidence exists in other countries (Sardon and Bergouignan 2005; Régnier-Loilier and Divinagracia 2010; Chandra et al. 2018; Cypryjański 2019; Aassve al. 2021). The fact that during the 20th century in Spain the only negative figures for natural population growth were in 1918 due the influenza pandemic and in 1939 due to the Civil War (Cabré, Domingo, and Menacho 2002) reinforces our findings. The observed negative impact of the first wave of Covid-19 on birth rates is also consistent with recent research (Aassve al. 2021; Pomar et al. 2022).

This study suggests that in Spain the overall monthly pattern of births was remarkably stable for at least a century (1860–1960), after which it began to slowly change, taking a new shape over several decades. While gradual changes in the shape and amplitude of seasonality appear to be associated with socioeconomic change, there is a clear connection between dramatic seasonality changes and isolated social/health phenomena, mainly pandemics and wars.

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