

The Human Fertility Database

# Short-Term Fertility Fluctuations Data series (STFF) – Methodological note

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## Background

The **Short-Term Fertility Fluctuations (STFF)** data series is a recent addition to the [Human Fertility Database](#) (HFD), providing up-to-date indicators on monthly trends in fertility. This new data resource was developed to meet the need to monitor and study the impact and consequences of the COVID-19 pandemic for the fertility trends (Beaujouan, 2021). The coronavirus outbreak and unprecedented counter-measures adopted by countries had wide-ranging effects on social and family life (Settersten et al., 2020), which reflected in the fluctuations of population-level fertility (Aassve et al., 2020; Luppi et al., 2020; Aassve et al. 2021; Sobotka et al. 2023). While the initial objective of the STFF series was to provide timely fertility data for monitoring and examining pandemic-induced fertility changes, in the long-term perspective this data project aims to facilitate research on short-term fertility responses to a variety of events, producing marked shifts in the fertility trends at the population level. The analysis of monthly fertility changes can be insightful not only in relation to such severe events like pandemics, wars, economic crises, or natural disasters, but also to various contextual factors that have strong impact on childbearing behaviour (e.g., important changes in family-related policies or legislation) (Sobotka et al., 2005).

The main goal of the STFF is to provide the most recent monthly fertility data, including monthly birth counts and (for selected countries with more stable and reliable data) monthly estimates of total fertility rates (TFR). Since crude birth counts and TFRs do not allow direct comparison across countries and over time because of the seasonality effect in childbearing, we also publish seasonally and calendar adjusted monthly birth counts and TFRs.

For many countries included in this series, data on monthly birth counts are available with a delay of only a few months. The largest part of the STFF data comes from the HFD<sup>1</sup>. Data for the most recent months, as well as full datasets for countries that are not included in the HFD have been collected from national statistical offices. It is noteworthy that in many cases, the most recent data are preliminary estimates and are therefore subject to change.

## Data

The STFF series provides open and user-friendly access to data on monthly fertility. The series includes two types of indicators: 1) actual counts of live births and TFRs by month and 2) seasonally- and calendar-adjusted birth counts and TFRs by month. All data are provided under CC-BY 4.0 license<sup>2</sup>. The data series is supplemented with country-specific documentation provided in the metadata file. For each country, it includes information about data availability, data definitions, regularity of updates, known restrictions or modifications, as well as precise references to the original data sources. Original birth counts, that are used to produce the output indicators, are also available in a standardized format. The format and structure of the STFF data files and the applied methods are described in the

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<sup>1</sup> In the HFD, data on monthly birth counts can be found in section “Input Data”, available on each country page. The HFD tries to collect the longest possible time series of these data. The earliest year for which monthly birth data are available is 1840 (the Netherlands). The HFD compilation of monthly birth counts consists of official data that were provided or published by national statistical offices. Data from 2000 on are used also for the STFF collection.

<sup>2</sup> See <https://creativecommons.org/licenses/by/4.0/> for details.

subsequent sections of this document. The STFF is primarily focused on (but not limited to) the countries included in the core HFD database.

## Data quality issues

The majority of countries covered in the STFF are part of the HFD collection or are expected to be included in the core HFD soon. The HFD follows strict data quality criteria for the inclusion of individual countries. In particular, the database is restricted only to countries with fully functioning vital registration systems, covering close to 100 percent of their population.

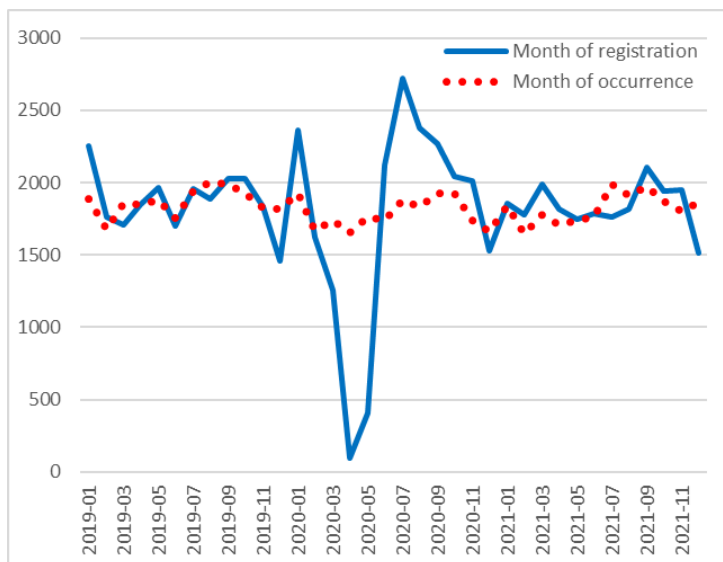
Monthly statistics have certain features that call for separate consideration. Most importantly, births by date of occurrence are preferred to births by date of registration for analysis of monthly fertility changes because statistics by date of registration are typically affected by artificial fluctuations caused by delayed registrations of births (e.g., due to the closure of vital registration offices during the lockdown). However, for some countries, monthly birth counts are available only by date of registration. There is no way to convert date of registration into date of occurrence. For each country, the type of input data and other important details are described in the metadata file. This information is available also in country-specific input files: a field “Type” indicates whether original birth counts are by month of occurrence or by month of registration. In addition, special checks are carried out on the original data to exclude the most distorted data series from the output statistics.

Based on the example of Northern Ireland and Scotland, we demonstrate how an analysis of data on births by month of registration can lead to misleading conclusions. Figure 1 and Figure 2 present changes in monthly birth counts for these two countries. The graphs for both countries show that in 2020, the registered live births collapsed close to zero in April in Northern Ireland and in April-May in Scotland, with less than 100 births reported in these months. This was followed by an upturn, with a maximum reported in July 2020. The described swift shifts in monthly births were caused by the postponement of birth registrations. Most of the registration offices were closed in mid-March and restarted only in late June in 2020<sup>3</sup>. For this reason, we decided to exclude these two data series from the STFF output file. However, from June 2021, in response to the increased demand for monthly number of births, the National Records of Scotland started publishing data by month of occurrence for the period from 1990 onwards. Similarly, the Northern Ireland Statistics and Research Agency started publishing monthly numbers of births by month of occurrence for the period from 2006 onwards. Occurrence data for both countries were included in the STFF. Figures 1 and 2 shows differences between the data by month of registration and by month of occurrence for the two countries.

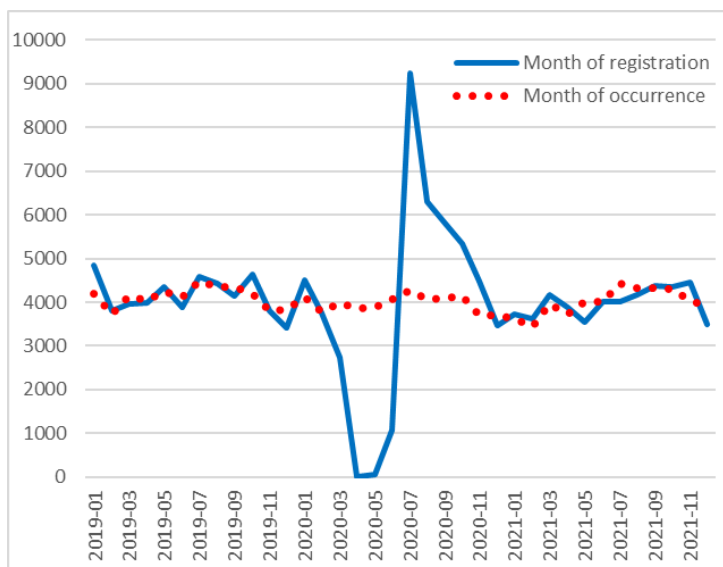
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<sup>3</sup> See <https://www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme/vital-events/general-publications/weekly-and-monthly-data-on-births-and-deaths/monthly-data-on-births-and-deaths-registered-in-scotland>

**Figure 1. Monthly birth counts, Northern Ireland**



**Figure 2. Monthly birth counts, Scotland**



It is generally important to be cautious when using registration births datasets included in the STFF because births by month of registration may display fluctuations and irregularities that reflect not the true underlying trends in births, but rather a pattern of delayed registration. For instance, distortions in data may appear because late-reported births are added at the end of a calendar year. Furthermore, due to delayed registration, birth statistics might be incomplete for the last few months; statistical offices may still be revising these data backward in the course of the next updates.

Births with unknown month of birth are not re-distributed in the STFF. In the output files, monthly distributions of births are presented as they are in the original data sources, and no adjustments for potential data quality problems, including undercounts, are performed. No data smoothing is applied either. All known country-specific data quality issues are documented in country-specific sections of the metadata file. In all cases, ***the user must take responsibility for understanding the limitations of data provided in the STFF series.***

## Updates

During the early stage of the project, the STFF series was updated frequently. Presently, the updates are carried out twice a year, around April and October. New data series are still being added into the STFF, should data of sufficient quality become accessible for some country(-ies).

## Output data

The STFF output data are provided in pooled and country-specific data files. The pooled data files are provided in two different formats, MS Excel \*.xlsx and comma-separated values \*.csv, whereas country-specific data files are available in comma-separated values format (CSV). The pooled data files include STFF.xlsx, STFF.csv, STFFadj.xlsx, and STFFadj.csv. The first two files (i.e., STFF.xlsx and STFF.csv) contain all data on monthly birth counts collected for the STFF series and monthly TFRs that were calculated using these data. The data cover the period of time starting from January 2000 until the most recent month for which data were available at the last STFF update. Similarly, the other two pooled data files (i.e., STFFadj.xlsx and STFFadj.csv) include seasonally- and calendar-adjusted series of monthly births and monthly TFRs for selected countries for the period since 2012.

Country-specific information about data availability, completeness, data sources, and other specific features of included data are provided in the metadata file (STFFmetadata.pdf).

The STFF.xlsx and STFF.csv files have an identical structure, and each line (record) includes the following fields:

- 1) The first three columns identify country, area, and year. We use standard HFD/HMD country codes<sup>4</sup> based on ISO-3 definitions.
- 2) The next 12 columns (4 to 15) provide monthly birth counts starting from January. The missing values (usually for the last months of the current or the previous year, for which data are not yet available) are coded as dots (“.”).
- 3) Column 16 refers to births with unknown month of birth. The missing value (“.”) in this column is equivalent to zero. Zero is used only in cases when original (input) data contain information on births with unknown month of birth.
- 4) The column 17 shows total annual number of births.
- 5) The next 12 columns (18 to 29) provide monthly total fertility rates. The missing values (usually for the last months of the current or the previous year, for which data are not yet available) are coded as dots (“.”).
- 6) The last column 30 shows annual estimates of total fertility rates.

The files containing seasonally- and calendar-adjusted series of births have the same formats, except for the column for births with unknown month and total births. These two columns are left out in these data series.

The format of country-specific output files is analogous to respective pooled data files.

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<sup>4</sup> <https://www.humanfertility.org/Docs/formats.pdf>  
<https://www.mortality.org/cgi-bin/hmd/DataAvailability.php>

The first worksheet of the Excel files (STFF.xlsx and STFFadj.xlsx) provides a summary information related to the included data. The subsequent worksheets present country-specific data, i.e. one worksheet is devoted to data for one country.

The CSV data files (STFF.csv and STFFadj.csv) are optimal for data use in statistical packages. These are conventional comma-separated values files with all STFF data provided as one dataset.

The files containing data on monthly birth counts and (crude) monthly TFRs have the following heading (with each field matching the description above): *CountryCode, Area, Year, January, February, March, April, May, June, July, August, September, October, November, December, UNK, TOT, TFRJanuary, TFRFebruary, TFRMarch, TFRApril, TFRMay, TFRJune, TFRJuly, TFRAugust, TFRSeptember, TFROctober, TFRNovember, TFRDecember, TFRTOT*

The files containing data on seasonally- and calendar-adjusted monthly births and monthly TFRs have the following heading (with each field matching the description above): *CountryCode, Area, Year, January, February, March, April, May, June, July, August, September, October, November, December, TFRJanuary, TFRFebruary, TFRMarch, TFRApril, TFRMay, TFRJune, TFRJuly, TFRAugust, TFRSeptember, TFROctober, TFRNovember, TFRDecember, TFRTOT*.

### Original (input) data

The STFF input data files are country-specific comma-separated values (CSV) files. The whole set of country-specific input files is available for download as a single zip archive. Country-specific files are named as XXXstff.csv, where XXX is a 3-digit ISO country code with additional characters for sub-populations (including 3-7-digits, all uppercase letters). Each country-file contains standard headings (first line), which represent the field identifiers, and a comma (",") is used as a field delimiter. Missing values are coded as a single dot (".").

#### Headings:

*PopName, Area, Year, Month, Vital, Births, RefCode, Status, Type*

Each record refers to the birth count for one particular combination of month, year, area, and population. The formats of the input data fields are as follows:

- 1) *PopName* (the same code 'XXX' as in the file name): country or area code.
- 2) *Area* (2-digit, numeric): territorial/country coverage. The description of these codes must be provided in the metadata. This field serves to reflect territorial (or country) coverage. For most countries, only Area=1 (the whole country) is used.
- 3) *Year* (4-digit); year in which the births occurred or were registered (depending on the type of provided data).
- 4) *Month* (numeric 1-12, 'UNK' for unknown, 'TOT' for total): month in which the births occurred or were registered (depending on type of provided data).
- 5) *Vital* (one-digit numeric; '1' for live births, '2' for total births): vitality of births.
- 6) *Births* (numerical field, no fixed length): number of monthly births.

- 7) *RefCode*. Reference to the source of data. Complete references to the sources are available in the metadata file. We use standardized reference codes for the whole HFD. It means that the code used in the STFF will refer to the same data sources used in the core HFD.
- 8) *Status* (one character): official status of the data where 'F' stands for final data and 'P' for preliminary/provisional estimates.
- 9) *Type* (one character): type of the provided data where "O" stands for births available by month of occurrence and "R" for births by month of registration.

## Methods

There are two types of data series in the STFF: original/crude data and seasonally- and calendar-adjusted estimates. Each of the two data series includes data on birth counts and total fertility rates (TFR).

### Birth counts

No specific methods were applied to birth counts provided in the STFF output data files. The data were collected and transformed into a user-friendly format. Nevertheless, several specific features of this dataset should be noted:

1. Quality of every data entry is checked before publishing. The standardized checking procedure includes all standard HFD data quality checks that are applicable to data on monthly birth counts. In order to be published, the country's data must meet the HFD data quality criteria (Jasilioniene et al., 2015). In particular, the country must have an almost complete vital registration system.
2. No adjustments to the official data are implemented. However, all known data quality issues are documented in the metadata file. If it is one of the countries included in the core HFD, a more extensive data description can be found in the HFD background and documentation file for this country.
3. As a rule, data for the last several months are preliminary and are subject to change in the future. Moreover, in some countries preliminary data are published by date of registration, and only the final estimates are released by date of occurrence. In such cases, the data series has limited comparability across time.

### Total Fertility Rate

At the next step, we estimate monthly total fertility rates (TFRs). Since the STFF does not include age-specific birth counts, we cannot use standard methods of calculating the TFR. The approach that we employ is based on the empirical country-specific relationship between the annual general fertility rate (GFR) and the TFR. For the calculation of the GFR, country-specific population exposure estimates are required.

### Monthly population exposures

For most of the cases, we use annual population exposures from the Human Mortality Database (HMD). However, for the most recent years, for which HMD population exposures are not available, we use forecasted values, directly taken from the Short-Term Mortality Fluctuations database (STMF), which applies the Lee-Carter model to extrapolate annual death rates. This model is fitted using the available HMD data series. The death rates are used to estimate age-specific population exposures and death counts under the assumption of zero migration (see details in Jdanov et al. 2021). Using the

annual average population estimates, we estimate monthly population exposures by linear interpolation. We consider annual population exposures as mid-year estimates (i.e., on 1<sup>st</sup> July of a given year). We use population exposure for women of the ages 15 to 44:  $E_y(15,44) = \sum_{x=15}^{44} E_y(x)$ . For January to June, we interpolate the monthly values using annual exposures for a given year  $y$  and the previous year,  $y-1$ , as:

$$E_{m,y}(15,44) = \left[ \frac{i}{24} * E_y(15,44) + \left( 1 - \frac{i}{24} \right) * E_{y-1}(15,44) \right] \cdot d_m \quad (1)$$

where  $i = 2 * (m + 5) + 1$ ,  $m$  is month number (1 to 6),  $E_{m,y}$  is population exposure in month  $m$  (of the year  $y$ ), and  $d_{m,y}$  is a proportion of the length of month  $m$  in year  $y$ . For July to December ( $m \in (7,12)$ ), we interpolate between the annual exposure for a given year  $y$  and the next year,  $y+1$ , as:

$$E_{m,y}(15,44) = \left[ \frac{i}{24} * E_{y+1}(15,44) + \left( 1 - \frac{i}{24} \right) * E_y(15,44) \right] \cdot d_m \quad (2)$$

where  $i = 2 * (m - 7) + 1$ .

The proportion of the length of month  $m$  in year  $y$  is calculated as  $d_{m,y} = D_m/D_y$ , where  $D_m$  is the number of days in month  $m$  and  $D_y$  is the number of days in a year  $y$ . In the case of calendar and seasonal adjusted indicators,  $d_{m,y} = 1/12$ .

### General Fertility Rate and the ratio between the GFR and the TFR

Combining monthly numbers of births with monthly population exposures allows estimating the monthly general fertility rate (GFR) as follows:

$$GFR_{m,y} = \frac{B_{m,y}}{E_{m,y}(15,44)} \quad (3)$$

The GFR expresses birth rates among the female population of reproductive age (defined as 15–44 here) and is therefore considered to be less affected by cross-country differences in population structure by age and sex than the crude birth rate (CBR), which is related to total population size. To derive an indicator of the total fertility rate, we assume that there have been only gradual shifts over time in the relative age distribution of the population of women of reproductive age during the last years and that the relationship between the GFR (which pertains to total female population of reproductive age) and the TFR (which reflects a finer-grained age distribution of women) is therefore relatively stable.

Thus, to estimate the monthly TFR in the absence of age-specific data, we use a ratio  $r_{m,y}$  of the GFR to estimate the TFR:

$$TFR_{m,y} = r_{m,y} * GFR_{m,y} \quad (4)$$

We start from the annual ratio  $r_y$ , which we calculate using annual data from the core HFD:

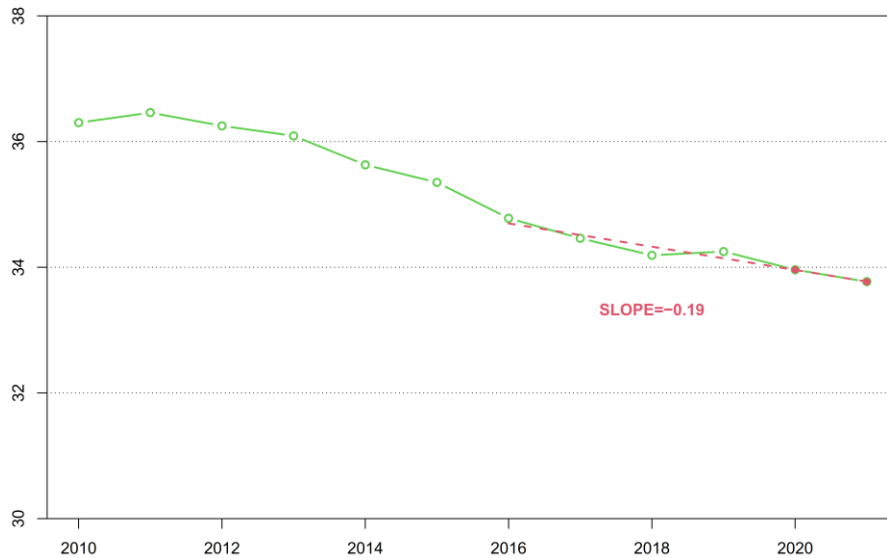
$$r_y = \frac{GFR_y}{TFR_y} \quad (5)$$



where  $TFR_y$  are annual TFRs from the core HFD. For the years, for which HFD estimates are not available but official TFR estimates are published, we use the official estimates. Annual GFRs are calculated using birth counts and population exposures from the HFD. We use forecasted population exposures and STFF birth counts for the years, for which data are not available in the core HFD but are included in the STFF.

To estimate  $r_y$  for the years with incomplete data, we use linear regression fitted on the last five available years (see Figure 3 for an example of Spain). Then we estimate monthly  $r_{m,y}$  by linear interpolation of annual  $r_y$ : the annual indicator for any year  $y$  is assumed to pertain to the mid-year (1<sup>st</sup> July) of that year, and the monthly values of the ratio are then interpolated from the annual values of the preceding ( $y-1$ ) and the subsequent years ( $y+1$ ) in a similar way as the derivation of monthly population exposures in equations 1 and 2 above.

**Figure 3.** Observed GFR/TFR ratios (\*1000), 2010–2019, and projected (extrapolated) GFR/TFR ratios, 2020–2021, Spain



A crude indicator of monthly numbers of births is useful for estimating excess births in a given month but it does not allow direct comparison across countries and over time because of seasonality of births. To provide comparable indicators, we apply seasonal and calendar adjustments. First, we calculate seasonally- and calendar-adjusted monthly birth counts. Second, we calculate seasonally- and calendar-adjusted monthly total fertility rates.

### Seasonality and calendar adjustment of monthly births

Adjusted monthly time series are obtained in several steps. Here we follow the general framework defined by Calot (1999) and Calot and Sardon (2004), although the details in each step might differ. These computations are not performed for all countries included currently in the STFF, but only for a subset of countries with more reliable data. The countries selected for the monthly TFR estimations must be included in both the HFD and the HMD (to obtain estimates of population exposure), and the monthly birth data must pass through internal quality checks. Countries with high fluctuations in birth data, and some countries which publish recent births by month of registration rather than by month of occurrence, are excluded. Excluded are also countries where the currently available data series do

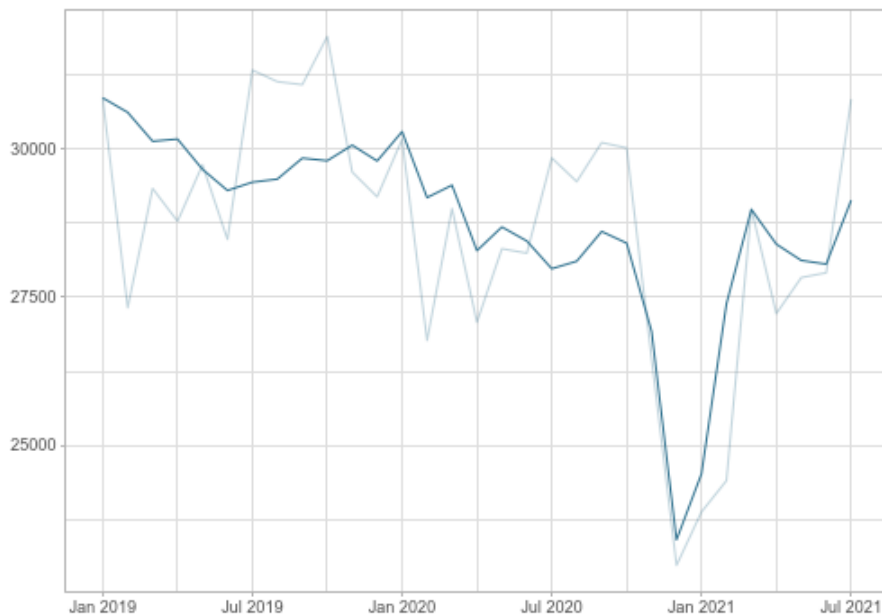
not cover the recent period and end in or before December 2020. For more details on country-specific data, please refer to the STFF metadata file.

The monthly numbers of births are first seasonally adjusted using the R package `seasonal` (Sax and Eddelbuettel, 2018), which provides an interface to the seasonal adjustment software X-13ARIMA-SEATS (US Census Bureau, 2021). The latter program is among the recommended seasonal adjustment methods in the European Statistical System Guidelines (Mazzi et al., 2018).

The adjustment is organized in two steps. First, it accounts for weekday variations of births (calendar adjustment) and potential outliers, using a regression model with ARIMA errors (regARIMA). Then, a seasonal filter is applied to the calendar- and outlier-adjusted series. We use the X11 seasonal filter, which is a semi-parametric method based on moving averages. The quality of the seasonal adjustment is assessed by checking whether the residuals of the ARIMA model are uncorrelated and normally distributed and whether the seasonally adjusted series for each country is free of any residual seasonality.

For this analysis, we derive the seasonally adjusted monthly numbers of births from January 2012 until the latest available observation, which is then used to compute monthly total fertility rates. Figure 4 illustrates the observed and seasonally adjusted monthly birth series for Spain in 2019–2021.

**Figure 4.** Observed (thin grey lines) and seasonally-adjusted (thick blue lines) monthly numbers of births, Spain, January 2019 to July 2021



## Seasonally- and calendar-adjusted total fertility rates

Monthly adjusted TFRs are calculated using adjusted monthly birth counts instead of observed monthly counts in equations (3)-(4):

$$\widehat{GFR}_{m,y} = \frac{\widehat{B}_{m,y}}{E_{m,y}(15,44)} \quad (6)$$

and

$$\widehat{TFR}_{m,y} = r_{m,y} \cdot \widehat{GFR}_{m,y}, \quad (7)$$

where  $r_{m,y}$  is defined by linear interpolation of  $r_y$  from the equation (5).

## History of the project and research team

The outbreak of the COVID-19 pandemic had a wide-ranging impact on all facets of people's life (MacKellar and Friedman, 2021; Settersten et al., 2020). Although the questions of population health and mortality as related to the COVID-19 have been at the centre of public attention since then, the interest in the impact of the pandemic on fertility has been growing too. The work on the STFF data project started in November 2020. The idea of this project was inspired by the success of the Short-Term Mortality Fluctuations (STMF; <https://mpidr.shinyapps.io/stmortality/>) data series, launched by the Human Mortality Database team in May 2020. The STFF series are based on monthly counts of births. In contrast to mortality, due to a smaller impact of short-term events and shocks, weekly fertility data are less important for scientific research and are not routinely published by most statistical bodies. Most of the national statistical offices in highly developed countries publish monthly reports regularly during a calendar year. Unlike the final annual reports, these publications provide only preliminary data on monthly counts of live births. The current project carries the potential to be developed into a more ambitious project in the future, aimed at collecting monthly birth counts by parity and age of the mother and estimating respective short-term fertility rates.

The STFF series constitutes a part of the HFD project, which is a joint initiative of two research teams, from the Laboratory of Demographic Data at the Max Planck Institute for Demographic Research (MPIDR) and the Vienna Institute of Demography (VID) at the Austrian Academy of Sciences.

Dmitri Jdanov (MPIDR), Tomáš Sobotka (VID), Aiva Jasilioniene (MPIDR), and Kryštof Zeman (VID) designed the layout of the STFF data series and initiated the data collection. Ainhoa Alustiza Galarza (formerly MPIDR) was responsible for organizing the data collection and communicating with the data providers; she compiled the core part of the STFF metadata file. Kryštof Zeman developed a set of standardized data quality checks. László Németh (MPIDR) developed the Visualization Toolkit<sup>5</sup>, which enables instant calculation and visual inspection of monthly fertility variations across countries. Maria Winkler-Dworak (VID) developed the methodology for calendar and seasonal adjustment of monthly births, and Kryštof Zeman developed the estimation procedure for the total fertility rates. Karolin Kubisch (MPIDR) organizes the work of MPIDR Student Assistants helping with data collection and

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<sup>5</sup> <https://mpidr.shinyapps.io/stfertility/>

contributes to the STFF data processing. Aiva Jasilioniene coordinates the STFF project work and is responsible for communication with STFF data users.

## Acknowledgments

The publication of the STFF data series would not have been possible without the support of the Max Planck Institute for Demographic Research (MPIDR) in Rostock, Germany and the Vienna Institute of Demography (VID) of the Austrian Academy of Sciences. The STFF research team is also very grateful to the MPIDR Student Assistants for helping with data searches and data reorganization.

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