Genus

Investigation of gender differences in stillbirths in Italian regions at the turn of the nineteenth century

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Abstract

Data quality issues have hindered the analysis of the determinants of stillbirths in the years following Italian unification. By exploiting panel data techniques to take into account the possible effect of stillbirth misreporting, this paper investigates the relationship between seasonal agricultural workload and the number of male and female stillbirths in the Italian regions at the turn of the twentieth century (1883–1913). We found that although stillbirth rates were lower for females, agricultural workload seasonality had a more substantial effect for them. We suggest that this finding may be rationalised through the adaptive sex ratio adjustment hypothesis.

Keywords: Stillbirths, Adaptive sex ratio adjustment hypothesis, Fixed effects model, Agricultural workload, Seasonality

Introduction

Hard physical labour has been associated with a higher risk of adverse pregnancy outcomes and stillbirth (e.g.Cai et al., 2019; McDonald et al., 1988; Reid, 2001; Walker et al., 1999). For instance, by employing data from Derbyshire, England (1917–1922), Reid (2001) showed that infants whose mothers worked during pregnancy were over 50 per cent more likely to have been stillborn than children whose mothers did not. The possible causes of these adverse outcomes have been attributed to reduced maternal blood pressure and/or blood flow to the uteroplacental unit resulting in increased uterine contractility and reduced foetal development (Palmer et al., 2013). It could also be argued that working during pregnancy may increase the risk of incurring mechanical trauma caused by working activities.

This paper investigates the relationship between seasonal agricultural workload and the number of male and female stillbirths in the Italian regions at the turn of the twentieth century (1883–1913). Although industrialisation was already underway in some northern regions (i.e., Liguria, Piedmont and Lombardy) by that time, the Italian kingdom was still considered a highly agriculture-led economy (see Daniele et al., 2018).[1]

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[1] The 1911 census reported that even in Lombardy, the most industrialised region at the time, the percentage distribution of the population employed in agricultural activity was still 46.3%.

After providing qualitative evidence about the important role of women in agricultural activity,[2] Ruiu and Breschi (2020) noted that troughs were evident in the seasonal pattern of live births about 9 months after the summer period. During that period, agricultural workload is at its highest intensity, while the harvest was not yet available. According to energy balance theory (Ellison et al., 2005), this should imply a negative energy balance, which in turn might have reduced the number of conceptions and subsequently that of births some months later. This seems to be the case for male babies. Indeed, according to the literature (see, e.g., Cagnacci et al., 2003), fewer males are conceived in sub-optimal conditions than females. In particular, using early pregnancy ultrasound examinations, Cagnacci et al. were able to precisely identify the time of conceptions of about 14,000 children born in Modena during the period 1995–2001. They concluded that the M/F ratio at conception showed an evident seasonal rhythm, with a prevalence of females in seasons with reduced fertility, and by contrast, an increased prevalence of males in seasons with increased fertility. The adaptive sex ratio adjustment hypothesis developed by Trivers and Willard (1973) offers a rationale for these findings. According to this hypothesis, when maternal conditions worsen, a lower ratio of males to females is observed, and this adjustment may take place both before and after birth. From an evolutionary point of view, a biological mechanism could have emerged to cope with the extra effort required to raise a male relative to a female.

Interestingly, by employing data for US foetal deaths and live births for the period 1995–2004, Orzak et al. (2015) suggested that the sex ratio should decrease in the first week or so after conception (due to the higher male fragility in this stage), it then increases (due to higher female mortality in utero), flattens out about 20 weeks later and finally, after approximately 28 weeks, it decays gradually because of excess male mortality in the few weeks before the end of gestation. However, they did not confirm the presence of gender biases at conception. One of the most intriguing points in the work by Orzak et al. is that the risk of negative outcomes for females during the whole pregnancy would exceed the corresponding risk for males, thus challenging the traditional view, according to which we could expect higher male fragility (see, e.g., Lawn et al., 2016). A recent interesting review about in utero mortality can also be found in Rettaroli and Scalone (2021).

The hypothesis advanced in this paper is that a positive relationship should exist between the intensity of agricultural activity and the number of stillbirths registered after the gestation months. That is, a peak in the workload should, on the one hand, reduce conceptions, especially among males; on the other hand, because more female foetuses tend to be conceived during sub-optimal periods, we should expect more female stillbirths. This is simply because the female population is more exposed to the risk of a stillbirth than its male counterpart.

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[2] Although official statistics report only the occupation of male household members, this did not mean that women were not involved in the agricultural sector. The well-known "Inchiesta Jacini" on the conditions of the agricultural working class, which was carried out from 1877 to 1885, reported clear evidence regarding the involvement of women in various agricultural activities equally demanding as those carried out by men.

However, our data series do not allow us to establish whether these possible gender differences are caused by gendered differentiation in utero fragilities, as demonstrated by Orzak et al. (2015). Therefore, although we expect a stronger effect for females, without having data on conceptions, we are unable to give more prominence to one explanation (differential fragility dependent on the month of gestation) or the other (i.e., greater exposure due to the higher number of female conceptions in a high workload period).

Several data quality problems must be anticipated. First and foremost, our analysis is based on aggregate data, then, as in Ruiu and Breschi (2020),[3] data on the workload intensity of mothers are not available; however, marriage seasonality can be used as a proxy. In particular, the literature has highlighted that the seasonal pattern of marriages was heavily conditioned by the agricultural workload. In general, peaks in marriages were observed during low work intensity season (i.e., during the winter months), while troughs were common during the summer when the harvest of grain, maize and other cereals was carried out (Coppa et al., 2001; Lucchetti et al., 1996; Sanna & Danubio, 2008).

Second, although Italy recorded data on stillbirths, there are several issues related to underreporting (see Breschi et al., 2012; Manfredini et al., 2019). We shall discuss the latter issue briefly in the second section of this paper. However, it must be said that although misclassification and/or underreporting of stillbirths may characterise our data, there are no reasons to believe that these were gender-biased. Therefore, we believe that eventual gender differences in stillbirths are not driven by these problems.

These data quality issues have probably hindered the use of these time series data for analysing the determinants of stillbirths during the study period. Despite this, we believe that these data limitations can be tackled with appropriate data panel techniques. Moreover, it should be taken into consideration that, as expected, information on conceptions is not available, and therefore, several assumptions regarding the length of gestation must be made.

The remainder of this paper is organised as follows: in the next section, some clarifications about the stillbirth data are furnished. In the third section, the methods used for investigating the relationship between stillbirths and intensity of the workload are presented, while the fourth section is devoted to the discussion of the results. In the last section, final considerations are provided.

Definitions and problems related to the quantification of stillbirths

Vital statistics referring to stillbirths, live births and neonatal deaths are the result of the relative legal obligations, definitions and recording procedures. Since the beginning of the twentieth century, various efforts have been made to establish international definitions to control for problems of comparability, which usually derive from differences in national or even local legal definitions, data collection methods and declaration practices (Gourbin & Masuy Stroobant, 1995); even today stillbirths are under-reported and/or misclassified. Uniform rules for registering and reporting stillbirths have not yet been established in Europe (Blondel et al., 2018). As can be expected, problems regarding the

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[3] The reader is referred to Ruiu and Breschi (2020) for a detailed discussion of the rationales of this proxy variable.

quality and comparability of statistical data on stillbirths were even more prevalent in the past, when countries were characterised by very heterogeneous legal definitions as well as recording practices.

This is undoubtedly one of the reasons—albeit not the only one—for the limited number of studies dedicated to the analysis of stillbirths in the past, especially compared to the vast literature on infant mortality in Italy as well as in most Western European countries. Robert Woods has certainly contributed to "redress the balance", to use his own words (Woods, 2009, 1), by paying special attention to all issues arising from different legal definitions, methods for classification and recording procedures in several populations around the world. According to Woods's (2009) classification into four groups of countries, Italy with France, Belgium and Spain, constituted the third group, which was characterised by false stillbirths, as opposed to the 'Advanced countries' (Scandinavian states with a very early registration system), the 'Late countries' (Great Britain and USA), where registration began significantly later, and the developing countries where registration system does not exist or is still very defective. In particular, Woods observed that:

> *Several European countries [included in the third group] adopted and persisted well into the twentieth century with the practice of categorising deaths during the first hours after live birth as stillborn and of including them with the registered stillbirths. In consequence, registered live births were those infants born with vital signs (respiration especially) and who survived at least for 1–3 days. (2009, 77)*

In Italy, after national unification, the new Italian state adopted the concept of 'legal viability', which meant that the newborn was defined as 'born alive', if it was alive at the time of notification (it had to be reported within 5 days after delivery), while the newborn was considered as 'born not alive'—practically stillborn—if it had died at the time of notification, regardless of the condition of viability at birth.[4] Given the high infant mortality at that time, many newborns were recorded as 'born not alive' in the civil registration of births. Moreover, parents whose babies had died before the notification (aged less than 5 days) were exempted from the duty of presenting the newborn to the Civil officer, and for this reason neither a death certificate redacted by a medical necroscope [coroner] nor a corresponding record in the death registers existed (Breschi et al., 2012).

This became even more complicated when the General Directorate of Statistics gave contradictory instructions: the newborn babies who died before notification, but gave vital signs had to be recorded as babies born alive. This discrepancy between the legal and the statistical criteria caused differences amongst the Italian communes in the classification and recording of stillbirths and neonatal deaths (Breschi et al., 2012; Manfredini et al., 2019).

The statistical system of recording stillbirths had improved by the mid-1880s, especially in the northern regions of the country. However, the process was long and territorially diversified. According to Woods (2009, 82), "national rates of late-foetal mortality only reached credible levels during the early decades of the twentieth century, because

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[4] The first stillbirth records in Italy date back to 1863. A unique National Vital Statistics System (including stillbirths) was introduced almost immediately after the creation of the Italian Kingdom (1861). The realisation of a unique national vital statistics system (births, deaths and marriages) was extremely fast, considering the difficulties of homogenising the various recording practices inherited from the different formerly independent states of the Italian peninsula (Istat, 1961).
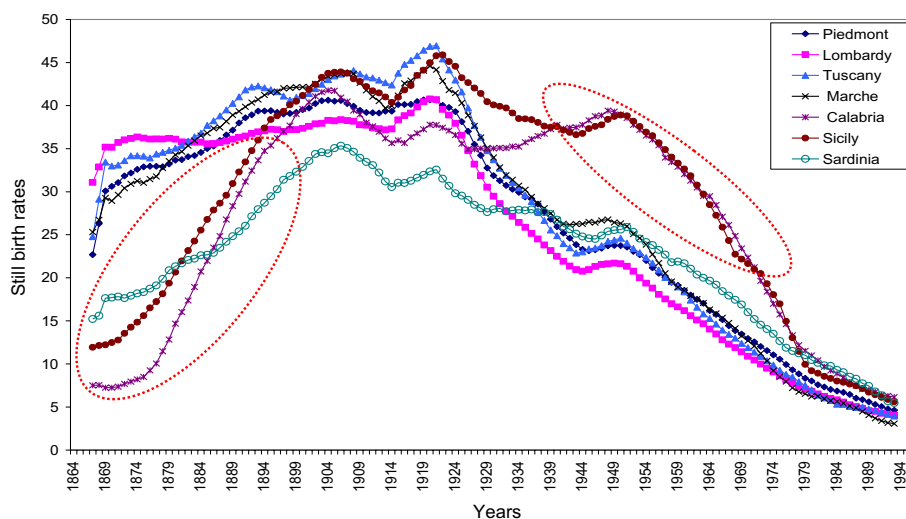
Fig. 1 Stillbirth rates in seven Italian regions (1864–1996). 7 year-moving averages

regional differences in registration quality had narrowed by then. Rates in the south rose to match those in the north and then stayed at a higher level longer". In particular, the southern/island territories were characterised by extremely low stillbirth rates, while the northern/central territories showed abnormally high rates (for a more detailed analysis of the north–south division, see Breschi et al., 2012). Figure 1 (borrowed from Pozzi & Breschi, 2018) illustrates the stillbirth rates for seven Italian regions during the period 1864–1996. The red circle on the left-hand side of the figure highlights the process of improvement in data quality, as described by Woods (2009), while the red circle on the right-hand side indicates the slow reduction of stillbirth rates in the southern regions after WWII.[5]

This regional heterogeneity in the registration process should be at least partly taken into account, on the empirical ground, when estimating the relationship between agricultural workload intensity and the number of stillbirths. Indeed, it may be argued that the measurement error in stillbirth resides systematically between the various regions for the different interpretations of the above-mentioned registration guidelines. These systematic errors in reporting stillbirths could, therefore, be ruled out using fixed effects methods for panel data.[6] Instead of focusing on inter-regional variation, fixed effects models would exploit the within-regional variation for estimations. Then, if misreporting depended on the local interpretation of the registrars for considering a newborn as born alive, the use of this technique should overcome the measurement error and reduce this potential bias source. However, to be cautious, it must be said that data panel techniques cannot solve

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[5] In Fig. 1, the northern regions are: Piedmont and Lombardy; the central regions are: Tuscany and Marche; and the southern regions are: Calabria, Sicily and Sardinia. It should also be mentioned that the Central statistical office of the Ministry of Agriculture, Industry and Commerce (MAIC) has cast doubts on the excessive incidence of stillbirths among total births in northern regions as well (see MAIC, 1879). Data from the north therefore cannot be considered free from distortion.

[6] Panel fixed effects can correct for biases in the registration if the assumption that errors were, to a degree, region-specific, time-invariant misinterpretations of the registration norms holds. Certainly, we cannot claim whether this assumption is true, but the persistence of the north–south differentials in stillbirth rates (as will be discussed later) throughout the study period may be an indication in favour of this hypothesis.

all data quality-related issues. In particular, it is not possible to distinguish between stillbirths and early neonatal deaths (within 5 days after birth). For simplicity, in the text, we refer to stillbirths, but it is very likely that we are also capturing some early neonatal mortality. Finally, we are not aware of a possible gender gradient in data accuracy. Hence, our hypothesis is that mis-recording and/or misclassification of stillbirths was equal for both males and females. We offer some support for this assumption in the discussion session.

Methods and results

First, we estimated the marriage seasonal factor for each region by dividing the log of the number of monthly marriages to determine its estimated trend. The trend was assessed using the Hodrick–Prescott filter, setting the λ parameter to 129,600, as suggested by Ravn and Uhlig (2002) for monthly data. This operation was carried out separately for male and female live births. Figure 2 exhibits the seasonal pattern of live births, stillbirths and marriages, grouped for the non-overlapping periods 1883–1898 and 1899–1914.[7]

Although the seasonal pattern of live births and stillbirths tend to coincide, they demonstrate slight discrepancies in December and January. This was due to the tendency of registering the births occurring in the last days of the year as if they had occurred in the first days of the following year. This was deliberately done to postpone for 1 year the compulsory military service for males and to allow female babies appear younger than they actually were (see Breschi et al., 2018).[8] The rationale for postponing female registration can be found in the so called net-value hypothesis, according to which the lower the value of the bride in the marriage market, the higher the price that a family had to pay (in terms of dowry size) to persuade the groom's household to accept their daughter (Botticini, 1999). In particular, Botticini found evidence that the older the bride, the larger the amount of the dowry paid by the bride's household to compensate for the her "lower value" on the marriage market.[9] Nonetheless, the delay was more common for males than for females. This is also evident in looking at the M/F ratio at birth, which was always higher in January and lower in December, especially in the southern regions (with the exception of Sardinia), where the delay was more common (see Fig. 3). In addition, it should be noted that there were no significant differences in the seasonal pattern of marriages between the two subperiods (see Fig. 2). This is in line with Ruiu and Gonano (2015), who classified all the Italian regions as having an agricultural workload-driven model of seasonality, at least until the first decade of the twentieth century.[10]

To support the idea that distortions in registering stillbirths were similar for both genders, we calculated the stillbirth rate (per 1000 births) separately for males and females. The trend of both rates was then estimated[11] and compared. The results are reported

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[7] Certain geographical regions have undergone significant territorial changes and therefore do not coincide with current regions. In particular, Aosta Valley was incorporated into Piedmont, while Molise was a province of Abruzzi. The territories of Trentino Alto Adige and the Venezia Giulia became parts of the Italian Kingdom only after WWI. The territory known as Friuli was part of Veneto; Friuli-Venezia Giulia was created after WWII by the fusion of the province of Udine (Friuli) with parts of Venezia Giulia that were not detached from the Italian territory as a consequence of the Treaty of Paris and its subsequent modifications.

[8] The use of the M/F stillbirth ratio has indeed been suggested by some authors to correct for the observed excess of male live births in January (see Breschi et al., 2018).

[9] Although the literature on the topic refers mainly to older periods, we suspect that similar norms were still in practice until the early twentieth century (or even later). The dowry system was definitively abolished in Italy in 1975 with the reform of the Family Law.

[10] See Chiassino and Di Comite (1972) for a very detailed description of the evolution of marriage seasonality in the Italian regions.

[11] The Hodrick–Prescott filter was also used in this case, setting the λ parameter to 6.25 (Ravn and Uhlig, 2002).
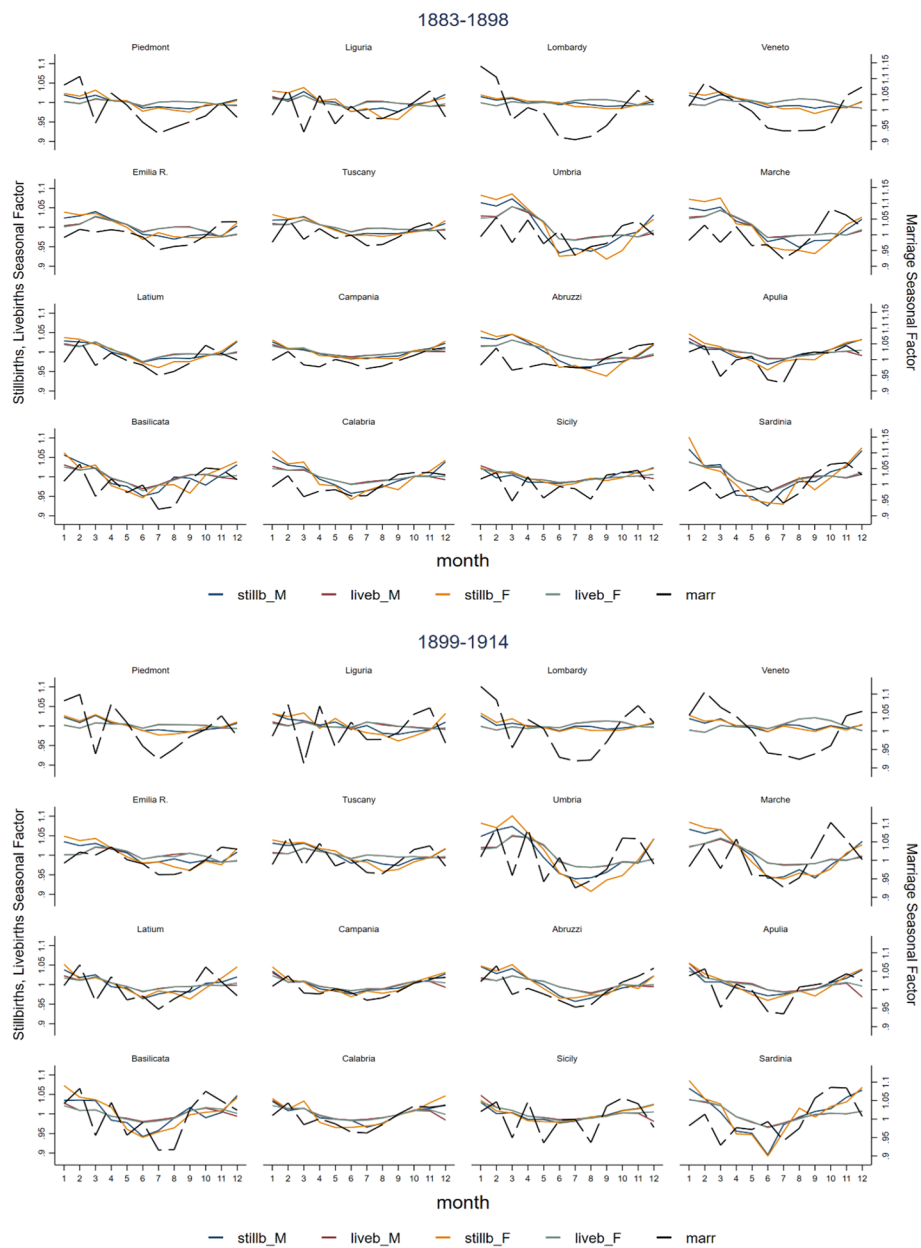
Fig. 2 Seasonal pattern of live births, stillbirths and marriages in the Italian regions, 1883–1914

in Fig. 4. If the registration of stillbirths was gender-biased, this would be reflected in a very different appearance in the representation of stillbirth rates. For instance, we would expect that stillbirths would be systematically lower/higher for females than for males in the southern regions, where the data are supposed of poorer quality, while we should expect to observe the exact opposite trend in the northern regions.
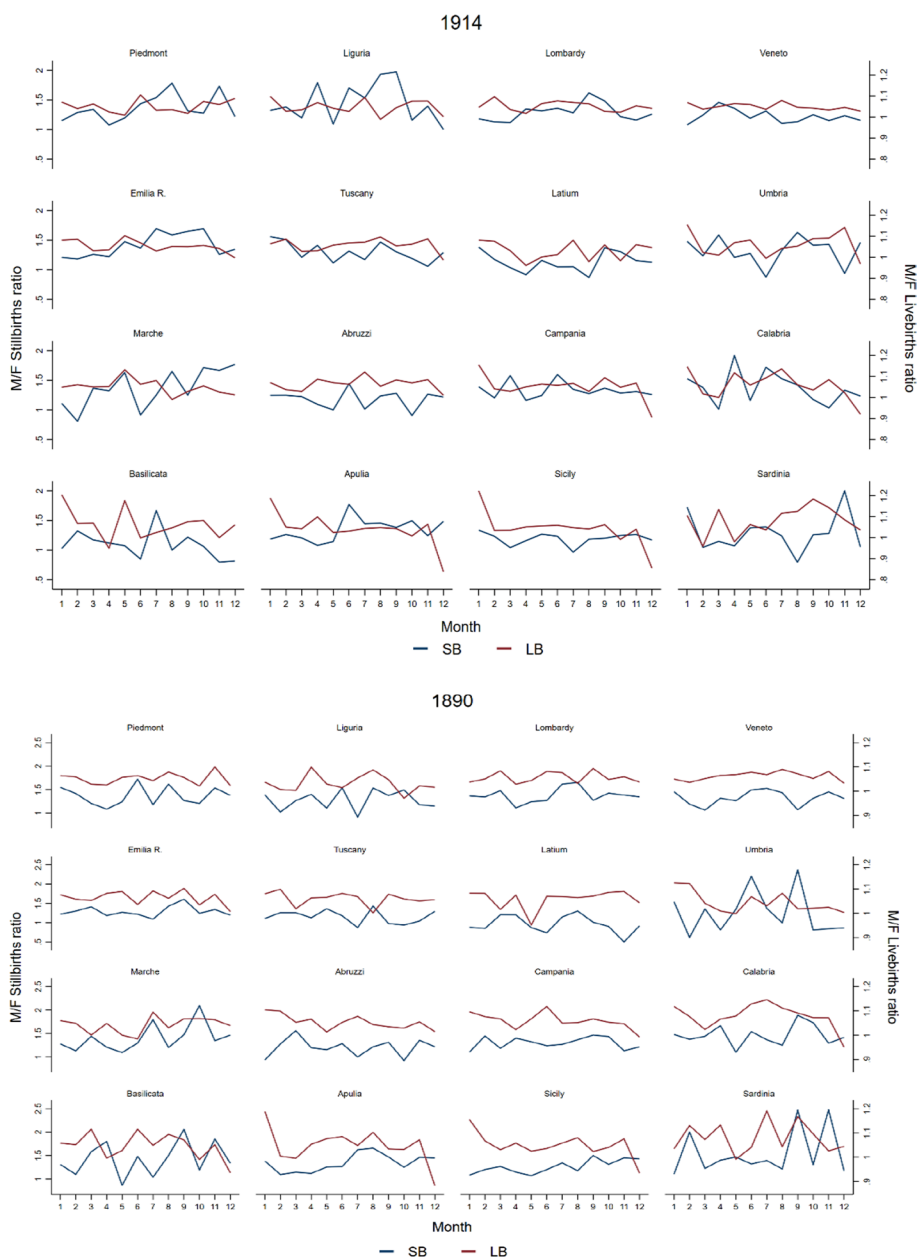
Fig. 3 M/F ratio for stillbirths and live births in the Italian regions, 1890, 1914

Finally, to test for the effect of agricultural work seasonality on the number of male and female stillbirths, we ran a fixed effect Poisson model using the monthly counts as the dependent variables.[12] In particular, the estimated model for male and female still-births is as follows:
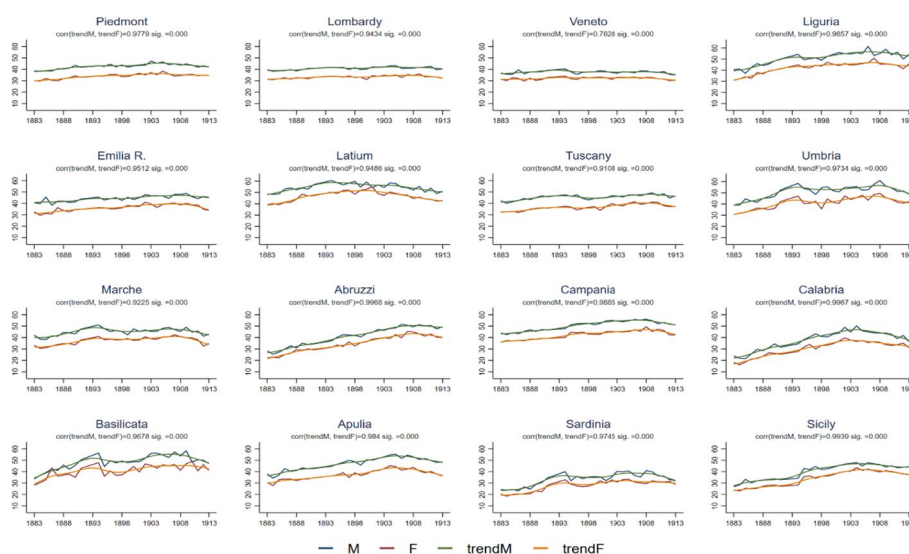

Fig. 4 Stillbirth rates in the Italian regions, 1883–1914

$$E\left(\mathrm{SB}_{it}^{g}\right) = \mu_{it} = \exp(\alpha_i + x_{it}\beta) \quad \text{where } \mathrm{SB}_{it}^{g} \sim \mathrm{Poisson}(\mu_{it}) \tag{1}$$

where SB is the monthly count of stillbirths in region i (= Piedmont, Lombardy, etc.) at time t (= 1883m1 − 1914m12) for gender g (= Male, Female). The explicative variables (x_{it}) refer to the seasonal factor of live births, the seasonal factor of marriages as a proxy of the seasonal pattern of agricultural workload, the lags of the marriage seasonal factors, a linear term to catch the trend of the time series (possibly caused by the improvement in the number of stillbirth registration) and a set of monthly dummies (using January as a reference). We included up to nine lags of the marriage seasonal factor to capture the possible effects of agricultural work intensity since conception. The underlying assumption was thus that the stillbirth occurred at the end of the gestation period. This assumption seems to be partly supported by Gini (1932), who reported that the vast majority of legitimate first-order stillbirths derived from marriages celebrated 7–8 months earlier.

The seasonal factor of live births was included in the model to control for a possible source of spurious correlation. Indeed, as can also be observed in Fig. 2, stillbirths and live births share similar seasonal patterns (see also Gini, 1932, who reached a similar conclusion). Thus, a significant relationship between the monthly number of stillbirths and the seasonal factor of marriages may be driven by the effect of the seasonality of the agricultural workload on the seasonality of live births (for the latter issue, see Ruiu & Breschi, 2020). Monthly dummies were included to take into account other possible confounding factors, such as monthly variations in temperature or rainfall (see Karlsson et al., 2019). We employed monthly dummies rather than

seasonal dummies to better control for other possible confounding factors. As suggested by Ruiu and Breschi (2020), marriage seasonality was influenced not only by agricultural workload but also by cultural norms. For instance, for a long time the Catholic Church had imposed a ban on marriages during the period of Lent, while in some territories, May was considered a non-propitious month for weddings. In addition, it seems reasonable to assume that sexual intercourse was, at least to some extent, inhibited by periods of religious penance, such as Advent or Lent. Therefore, we believe that monthly dummies are more likely to capture the effect of these culturally determined disturbing factors.

The term α_i refers to the regional fixed effects. Regional fixed effects account for the remaining unobserved territorial heterogeneity, such as, for instance, territorial differences in stillbirth registration, in addition to other regional unobserved factors (e.g., the quality of the health system, the structural characteristics of the local economy, cultural norms about female employment). The standard errors are robust to heteroskedasticity and serial correlation (on the correction of standard errors in the ambit of non-linear panel model, see Wooldridge, 1999). Finally, it is important to note that marriages were concentrated in months of low work intensity (see Ruiu & Breschi, 2020), so we expect that a negative coefficient would be associated with seasonal marriage factors.[13] The results are reported in Table 1 in columns 1 and 2, respectively.[14] Columns 3 converts the significant coefficients associated with marriage seasonality (or its lag) into incidence rate ratios (IRRs) to facilitate a quantitative interpretation of the associated effects.

Discussion

Figure 4 highlights that the estimated trends for female and male stillbirth rates are substantially the same for all regions (with the exception of Veneto, where the correlation coefficients are very close to one). In addition, the female stillbirth rate is lower than that for males in all Italian regions, while the distance between the two time-series seems to remain substantially constant over time. Hence, this seems to support the idea that the same under-registration errors were most likely committed for both genders throughout the study period.

Focusing on Table 1, the coefficient associated with marriage seasonality (MAR_SEAS) and those referring to its lags are, as expected, negative: the greater the concentration of marriages and the lower the intensity of the agricultural workload, the smaller the number of stillbirths for both male and female babies. Only the coefficients going from the second (2 months before birth, assuming a 9-month gestation) to the fifth lag (5 months before delivery) of the marriage seasonal factor are not statistically different from zero for both sexes. It is interesting to note that, according to Orzak et al. (2015), the sex ratio remains flat between week 20 and week 28 after conception (i.e., approximately 2 to 5 months before delivery). This may suggest that, during the period of gestation, external

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[13] For a robustness check, we have also run (1) a negative binomial regression; (2) a linear fixed-effect model using the log of the count as the dependent variable. The results are roughly the same. Associated tables are available upon request to the corresponding author.

[14] Note that the number of observations is equal to 6,000, because we have 12 monthly observations for 32 years and 16 regions. However, given that we have included the ninth lags for marriage seasonality into the model, we thus missed the first nine months of 1883.

Table 1 Effect of agricultural workload on the monthly count of male and female stillbirths

	(1)		(2)		(3) IRRs	
	SB_M		SB_F			
	B	SE	B	SE	SB_M	SB_F
Livebirth_Seasonal_Factor_M	3.963***	(0.381)				
Livebirth_Seasonal_Factor_F			4.388***	(0.368)		
Marriage_Seasonal_Factor	− 0.147***	(0.054)	− 0.224***	(0.073)	0.863	0.799
Marriage_Seasonal_Factor(− 1)	− 0.180*	(0.100)	− 0.165**	(0.068)	0.835	0.848
Marriage_Seasonal_Factor(− 2)	− 0.013	(0.086)	− 0.020	(0.074)	n.s	n.s
Marriage_Seasonal_Factor(− 3)	0.016	(0.058)	− 0.003	(0.062)	n.s	n.s
Marriage_Seasonal_Factor(− 4)	− 0.080	(0.084)	− 0.140	(0.096)	n.s	n.s
Marriage_Seasonal_Factor(− 5)	− 0.196**	(0.089)	− 0.256***	(0.090)	0.822	0.774
Marriage_Seasonal_Factor(− 6)	− 0.265***	(0.093)	− 0.379***	(0.078)	0.767	0.684
Marriage_Seasonal_Factor(− 7)	− 0.374***	(0.103)	− 0.306***	(0.101)	0.688	0.736
Marriage_Seasonal_Factor(− 8)	− 0.265***	(0.072)	− 0.347***	(0.071)	0.767	0.707
Marriage_Seasonal_Factor(− 9)	− 0.241***	(0.052)	− 0.292***	(0.057)	0.786	0.747
JAN	REF		REF			
FEB	− 0.036***	(0.014)	− 0.055***	(0.011)		
MAR	− 0.038*	(0.021)	− 0.078***	(0.018)		
APR	− 0.079***	(0.025)	− 0.122***	(0.024)		
MAY	− 0.070***	(0.026)	− 0.117***	(0.026)		
JUN	− 0.091***	(0.025)	− 0.132***	(0.030)		
JUL	− 0.084***	(0.025)	− 0.133***	(0.032)		
AUG	− 0.090***	(0.034)	− 0.151***	(0.040)		
SEP	− 0.100***	(0.036)	− 0.188***	(0.035)		
OCT	− 0.059*	(0.032)	− 0.113***	(0.029)		
NOV	− 0.020	(0.025)	− 0.066***	(0.023)		
DEC	0.053**	(0.027)	− 0.012	(0.018)		
trend	0.006***	(0.002)	0.008***	(0.002)		
N	6000		6000			

Auto-correlation robust standard errors in parentheses (Wooldridge, 1999)

n.s. not significant

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

factors such as the working activity of the mothers could have played a limited role in determining the imbalance in the sex ratio, and this also seems to be valid for stillbirths. However, we remark that this is only a possible hypothesis, because, in contrast with Orzak et al., we cannot provide any similar conclusions or correlations regarding the trajectory of sex ratio during gestation due to the limitations of our data set (as discussed earlier).

The most substantial coefficient for males is associated with the seventh lag and with the sixth lag for females. If we translate the coefficients associated with these lags into IRRs (column 3 in Table 1), we then observe an increase of one point in the marriage seasonal factor, leading to a decrease of 31.2% and 31.6% for male and female stillbirths, respectively. Again, this suggests that certain periods during gestation are more crucial for males, while others are important for females, thus confirming the idea of a different gender fragility pattern as proposed by Orzak et al.

However, it must be said that, apart from a few exceptions (i.e., the second and sixth lags), we find that the coefficients associated with marriage seasonality and lagged seasonality are larger for females than for males. This is coherent with the adaptive sex ratio adjustment hypothesis. If more females were conceived during periods of hard agricultural work, then they were also more exposed to a higher risk of being stillborn because of the activities carried out by mothers during gestation.

It is also important to note that the contemporaneous effect of marriage seasonality is significant for both sexes (again, the coefficient is larger for females). This indicates that if deliveries took place in a period of low work intensity, the number of stillbirths tended to be lower. We are likely capturing the effect of workload activity over a very few days before birth. Furthermore, it could be surmised that, in addition to the direct effect of the working activity of the mother, the availability of help and assistance from other women during childbirth was higher during seasons of low working intensity and this could have played a role in reducing the risk of stillbirths. However, it must be remarked that these forms of help were mainly based on empirical experiences and popular beliefs about fortune and misfortune rather than on medical knowledge (see Cicatiello, 2012; Pancino, 2021). Although the first midwifery schools opened in the second half of the nineteenth century with the explicit aim of improving the assistance furnished to mothers during childbirth, Cicatiello (2012) reported that the newly trained midwives faced several difficulties in being accepted in rural communities and then in standing in for the traditional/untrained *mammane*.[15] This casts doubts on the idea that the received assistance could help to reduce stillbirths.[16] Professional childbirth assistance, essential to reducing the number of stillbirths, was indeed very limited at the time, especially in rural and inland areas.

Considering the other variables in the analysis, coherently with Fig. 1, the coefficient associated with the linear trend is positive and highly statistically significant. Reasonably, the higher the seasonal factor of live births is, the higher the number of stillbirths. Hence, we can exclude the idea that the effect of the seasonality of agricultural workload on stillbirths passes through the correlation with birth seasonality. The significance of monthly dummies suggests that other factors not explicitly included in the model (for instance, temperature) may drive the seasonality of stillbirths (Ruiu and Breschi, 2017). It is also worth highlighting that January (but also December for males) was the month with the highest number of stillbirths. This is likely caused by the cold temperatures of that period. Indeed, December, January and February were also identified by Dalla Zuanna and Rosina (2011) as the months with the highest neonatal mortality (see also Derosas, 2009; Scalone & Samoggia, 2018). We are, therefore, probably capturing some of these deaths, given that the registration system in Italy did not separate stillbirths from early neonatal deaths (up to 5 days after delivery).

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[15] The term *mammane* was used especially in central–southern Italy to refer to women considered custodians of the knowledge necessary to help mothers during childbirths. Curiously, in modern Italian, this term is used in a negative sense to indicate those figures who practise clandestine abortion.

[16] The untrained *mammane*, prior to the employment of antisepsis techniques and sulpha drugs, were also considered as an important medium for the relatively high maternal mortality in Italy until the 1930s. On the levels of maternal mortality in Italy, see Manfredini (2020), Manfredini et al. (2020) and Manfredini and Breschi (2020).

Conclusions

The analysis of stillbirths in the period following Italian unification has been neglected by historical demographers because of the well-known problems with data quality. This paper investigated the relationship between agricultural workload and the monthly number of male and female stillbirths in Italy at the turn of the twentieth century. We believe that modern panel techniques can deal with the systematic measurement errors that were carried out primarily in the southern regions at that time. This is indeed one of the main strengths offered by employing fixed-effect models.

The importance of offering a better understanding of the determinants of stillbirths does not require explanation. The reduction of stillbirths is among the most important indicators of quality of care in pregnancy and childbirth. Indeed, one of the main targets of the Sustainable Development Goals is to shrink stillbirths to 10 per 1000 live births worldwide by 2035.[17] According to the World Health Organization, less than 10% of stillbirths reported in high-income countries are caused by congenital abnormalities, while the respective percentage for low-income populations is still unknown due to diagnostic limitations.[18] This means that the vast majority of stillbirths can be attributed to risk factors such as infections or the unhealthy/dangerous behaviours (e.g., smoking) of the parents and could be, in principle, at least in part avoided. At the turn of the twentieth century, the Italian economy was still based heavily on agriculture, while the population was subjected to both a high infectious load and undernutrition, conditions that are substantially similar to those existing in many developing countries. We thus believe that this paper can offer some indications for such populations. In particular, although the stillbirth rates were lower for females, we found that the agricultural workload seasonality had a more substantial effect for them than for males. This finding may be rationalised through the adaptive sex ratio adjustment hypothesis, as proposed by Trivers and Willard (1973), according to which, when mothers face a period of low-calorie intake, in addition to a reduction in the total number of conceptions (Ellison et al., 2005), more females than males are conceived as a sort of biological mechanism to cope with the extra effort required to raise a male child relative to a female one. However, if this sort of mechanism was operating, it would be reasonable to assume that more females were conceived during the summer period when the agricultural workload was particularly intense (including for women, given their active involvement in the process), but the harvest was not yet available. This also means that these babies were also more exposed to the risk of a negative outcome caused by the same intense working activity. We also find some support for the idea advanced by Orzak et al. (2015), according to which male/female fragility may be higher or lower depending on the period of gestation. However, on this point, the evidence is more nuanced, because, given the period under analysis, the available aggregate data do not provide any information on the start of gestation. Our findings also seem to be more coherent with the predominant view in the literature, according to which the risk of stillbirths is generally higher for males due to their higher in utero fragility. Indeed, if this is true, then this also represents a possible explanation for observing more females being conceived in difficult times. That is, the self-adaption

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[17] See https://www.alignmnh.org/issue/global-mnh-targets/.

[18] See https://www.who.int/health-topics/stillbirth#tab=tab_2.

mechanism may favour female conceptions, given that they have more of a chance of reaching the end of gestation as a live birth.

This work is not free from limitations. Because of the unavailability of data, other factors—such as climatic and environmental variables that may be important to explain stillbirths—have been ignored by our analysis. These factors are in part captured by regional fixed effects and monthly dummies in the estimated empirical model; however, it would be extremely interesting to enrich the model with these variables in the near future. In addition, it should be mentioned that fixed effects are a way to take into account unobserved time-invariant, region-specific factors (e.g., different regional registration practices, regional provision of health care, structure of the regional economy). Therefore, using fixed effect models should not be interpreted as a straightforward panacea for any kind of data problem, but instead as a technique that makes it possible to reduce the net error of a possible correlation of various unobserved factors at the regional level and our main explicative variable (in this case, marriage seasonality).

Finally, our work was based on the assumption that the same registration biases applied for both males and females. In principle, there are no indications to believe that stillbirth registration was subject to gender-based bias. We offered some support for this view by showing that female stillbirth rates were lower even in northern Italy, where the statistical system was more developed. In addition, given that the trends in male and female stillbirth rates were very similar in the southern regions, it is suggestive that the time series evolved in the same direction and there were not two different registration practices for the two genders.

Future directions for related research would be the inclusion of climatic variables in the analysis and conducting similar research at the individual rather than the aggregate level. In particular, it would be of particular interest to use birth registers to analyse the seasonality of both stillbirths and livebirths in relation to certain family characteristics (especially the profession of at least the heads of household), birth order, mothers' age and the prevalent type of agricultural activity carried in each community.

Declarations

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