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What explains the missing girls in nineteenth-century Spain?†

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Infant and childhood sex ratios in nineteenth-century Spain were abnormally high, thus pointing to some sort of unexplained excess female mortality. This article analyses internal regional variation and shows that certain economic and social factors mitigated gender discrimination against newborn and/or young girls. In particular, the presence of wage labour opportunities for women and the prevalence of extended families in which different generations of women cohabited had beneficial effects on girls' survival. Likewise, infant and child sex ratios were lower in dense, more urbanized areas.

Finding patterns of gender discrimination in infancy and childhood in historical Europe has proven a difficult task. According to Lynch, the European household formation system, together with prevailing ethical and religious values, limited female infanticide and/or the mortal neglect of girls early in life.[1] However, less extreme but perhaps more pervasive discriminatory practices may have had deleterious effects on the health of young girls. Several studies suggest that parents treated their sons and daughters differently via an unequal allocation of food, care, and workload which negatively affected girls' heights and mortality rates.[2]

In particular, recent research shows that infant and child sex ratios (the number of boys per 100 girls) in nineteenth-century Spain, and probably in other countries in southern Europe, were abnormally high, thus suggesting that some sort of gender discrimination was behind excess female mortality early in life.[3] Given the lack of anecdotal evidence on female infanticide or other extreme versions of mistreatment of young girls, this study argues that these patterns were the result of an unequal allocation of resources within households. In a period of extremely high infant and child mortality, a slight discrimination in the way young girls were fed or treated when ill, as well as in the amount of work with which they were entrusted, is likely to have increased female morbidity and, subsequently, mortality rates.

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[1] Lynch, 'European women'.

[2] Johansson, 'Deferred infanticide'; Humphries, '"Bread"'; Baten and Murray, 'Heights'; McNay, Humphries, and Klasen, 'Excess female mortality'; Horrell and Oxley, 'Gender bias'. However, Harris, 'Gender', does not find evidence of a systematic gender bias in mortality rates.

[3] Beltrán Tapia and Gallego-Martínez, 'Where are the missing girls?'.

By relying on a rich dataset at the district level in mid-nineteenth-century Spain, this article analyses regional variation in infant and child sex ratios in order to examine what lies behind the unbalanced sex ratios and thus disentangle the underlying motives driving excess female mortality early in life. We find that certain economic and social contexts mitigated gender discrimination against newborn and/or young girls. In particular, the presence of wage labour opportunities for women and the prevalence of extended families in which different generations of women cohabited are associated with lower sex ratios early in life. Likewise, infant and child sex ratios were also lower in dense and more urbanized areas. As explained in the text, it is plausible to argue that higher levels of economic complexity may have improved the relative value of girls and, consequently, increased their survival rates.

I

Discriminatory practices resulting in unbalanced sex ratios, such as female infanticide and the neglect of young girls, are well-known in South and East Asia, especially in India and China.[4] Economic factors have long influenced the perceived relative value of women, thus resulting in strong son preference. On the one hand, while sons provide a crucial labour force for the family farm, daughters' contribution to the household is seen as less relevant.[5] By increasing the recognition and economic independence of women, the existence of female employment opportunities helps counterbalance these trends.[6] Likewise, discrimination against girls seems to increase in adverse conditions due to the need to ration scarce household resources.[7] Extensive dowry systems also constitute a major drain on household resources, thus further disadvantaging young girls. Lastly, responsibility for old age support usually falls to sons, a moral obligation which is particularly important for the poor, who cannot save.[8]

On the other hand, religious and cultural practices also play a role in explaining son preference.[9] In India, China, and South Korea, for instance, sons alone are in charge of worshipping their ancestors. Christianity and Islam both explicitly prohibit infanticide, thus reducing the appeal of resorting to female infanticide as a way to control the sex of surviving offspring. Furthermore, in China, lineage is traced solely through the male, so failure to have a son implies the extinction of the family line, whose continuity is extremely important to the Confucian creed.[10] Kinship systems that isolate women from their original kin and keep them in a subordinate position in the household into which they marry are especially deleterious to women's status.[11]

[4] A. Sen, 'More than 100 million women are missing', *New York Review of Books*, 37, no. 20 (1990).
[5] Das Gupta, Zhenghua, Bohua, Zhenming, Chung, and Hwa-Ok, 'Son preference'.
[6] Klasen and Wink, 'Turning point'; Qian, 'Missing women'.
[7] Duflo, 'Women empowerment', p. 1054. Extreme events such as wars and famines also place families under severe resource constraints which lead to a rise in discrimination against daughters, as in Das Gupta and Shuzhuo, 'Gender bias'.
[8] Chung and Das Gupta, 'Son preference'.
[9] Das Gupta et al., 'Son preference'.
[10] Almond, Edlund, and Milligan, 'Son preference'.
[11] Dyson and Moore, 'On kinship structure'.

Das Gupta et al. argue that cultural factors prevail over economic ones when explaining gender discrimination in South and East Asia.[12] Patrilineal and patrilocal kinship systems exert a powerful influence, even when female job opportunities are widespread and when dowry systems do not constitute an important burden. Indeed these authors go a step further and argue that economic factors are themselves culturally constructed. These patterns do not vanish with economic development, which is normally associated with improving opportunities for women.[13] In this regard, the situation in China and India is telling because these countries have experienced worsening sex ratios at birth despite rapid economic growth.[14]

Direct evidence of gender discrimination against newborn and young girls in pre-industrial Europe is, however, limited. The European household formation system, together with prevailing ethical and religious values, seems to have limited the extent of female infanticide.[15] Although child abandonment was more widespread, foundling hospitals do not appear to have sheltered more girls than boys.[16] Many of these children, however, died before reaching such institutions, so further research in needed.[17]

Other studies suggest that parents treated their sons and daughters differently in nineteenth-century Europe, especially in adverse economic conditions or where wage labour opportunities for women were scarce.[18] Discriminatory practices, via an unequal intra-family allocation of food, care, and/or workload, are likely to have affected girls' health negatively, thus contributing to excess female mortality during childhood.[19]

Direct evidence of extreme discriminatory practices early in life is also lacking in the Iberian Peninsula. The literature analysing mortality rates has found no evidence of a female disadvantage at birth or during childhood.[20] Recent research, however, has shown that average infant and child sex ratios in nineteenth-century Spain were abnormally high, thus suggesting that some sort of gender discrimination was unduly increasing female mortality rates at those ages.[21] It

[12] Das Gupta et al., 'Son preference'.

[13] Dilli, Rijpma, and Carmichael, 'Achieving gender equality'.

[14] Declining fertility and the possibility of practicing sex-selective abortions thanks to ultrasound technology has reinforced previous trends. The relevance of cultural factors is confirmed by studies of migrants' reproductive behaviour in the US and Canada. See Abrevaya, 'Missing girls'; Almond et al., 'Son preference'. Recent research also reports extremely son-biased sex ratios at birth among Asian-born parents in Spain. See González, 'Missing girls in Spain'.

[15] Lynch, 'European women'.

[16] Ibid., p. 256.

[17] Likewise, Tikoff, 'Gender', argues that inferring gender biases from what is observed in a single foundling hospital can be misleading because different institutions could be catering for different age and gender groups.

[18] Johansson, 'Deferred infanticide'; Humphries, '"Bread"'; Pinnelli and Mancini, 'Gender mortality differences'; Schofield, 'Demographic response'; Baten and Murray, 'Heights'; McNay et al., 'Excess female mortality'; Horrell and Oxley, 'Gender bias'. Recent research on medieval England also suggests excess female mortality, probably arising from discriminatory practices. See Bardsley, 'Missing women'.

[19] Harris, 'Gender', however, does not find clear evidence of a systematic gender bias in differential mortality between boys and girls.

[20] See, for instance, Dopico, 'Regional mortality tables'; Gómez Redondo, *La mortalidad infantil*; Reher, Pérez Moreda, and Bernabeu, 'Assessing change'; Dopico and Reher, *El declive*; Ramiro-Fariñas and Sanz-Gimeno, 'Structural changes'; eisdem, 'Childhood mortality'; Reher and Sanz-Gimeno, 'Childhood mortality patterns'.

[21] Beltrán Tapia and Gallego-Martínez, 'Where are the missing girls?'. On infanticide and child abandonment in Spain, see Pérez Moreda, *Las crisis de mortalidad*, pp. 167–87; ídem, *La infancia*; Valverde, 'Illegitimacy'; Revuelta-Eugercios, 'Abandoned'; Berraondo, 'Los hijos'.

has been argued that, when infant mortality is extremely high, it is relatively easy to disguise the mortal neglect of infants as natural deaths. If this was the case, sex-specific mortality rates conceal the effect of discriminatory practices, thus making infant and sex ratios a better indicator for assessing the importance of these practices.[22]

This new evidence on unbalanced infant and child sex ratios is consistent with an unequal allocation of resources within the household, observed in terms of both nutrition and educational investments.[23] In this regard, preferential attention given to male infants and children may have reduced the survival rate of their sisters.[24] Boys seem to have been breastfed longer than girls, thus probably affecting girls' likelihood of falling ill.[25] Likewise, it has been shown that boys were comparatively better off than their sisters in a medium-sized Spanish town at the turn of the century, thus suggesting that some sort of gender discrimination was in place.[26]

II

As argued elsewhere, while sex-specific mortality rates are likely to hide the impact of unobserved discriminatory practices, infant and child sex ratios provide a better reflection of the cumulative impact of those practices.[27] In the absence of gender discrimination, the number of boys per 100 girls in different age groups tends to be remarkably regular. Comparing the observed figure to an expected gender-neutral sex ratio makes it possible to assess the importance of potential discriminatory practices. Historical sex ratios, however, cannot be compared directly to current ones. The biological survival advantage of girls was more visible in the high-mortality environments that characterized pre-industrial Europe. The subsequent excess male mortality, both in utero and early in life, thus implies that infant and child sex ratios in the past should have been much lower than today (sex ratios at birth in contemporary developed countries, including Spain, are around 105–106 boys per 100 girls).[28]

In particular, in societies where infant mortality rates are 250 deaths per 1,000 live births, as was the case in mid-nineteenth-century Spain, a gender-neutral infant sex ratio should be slightly below parity (100 boys per 100 girls; $p = 0.5$).[29] Relying on information for 17 European countries between 1750 and 2001 and using infant mortality rates as a proxy for material conditions, recent research estimates that, in countries with infant mortality rates around 250, child sex ratios (aged 0–4) should be around 99.5.[30] In contrast, the average infant and child sex ratios (aged

[22] Beltrán Tapia and Gallego-Martínez, 'Where are the missing girls?', p. 119. Statistics on births, deaths, and marriages in mid-nineteenth-century Spain were highly deficient; Gozálvez Pérez and Martín-Serrano Rodríguez, 'El Censo', p. 332. Moreover, Sánchez Aguilera, 'Las diferencias', p. 158, argues that female infant mortality rates obtained from those statistics are biased downwards.

[23] Borderías, Pérez-Fuentes, and Sarasúa, 'Gender inequalities'; Sarasúa, 'El acceso'.

[24] Dopico and Reher, *El declive*, p. 86; Reher and Sanz-Gimeno, 'Childhood mortality patterns', pp. 27–9.

[25] Gómez Redondo, *La mortalidad infantil*, p. 205; Borderías et al., 'Gender inequalities', p. 183.

[26] Reher and González-Quiñones, 'Parents', pp. 68–72.

[27] Beltrán Tapia and Gallego-Martínez, 'Where are the missing girls?', p. 119.

[28] Ibid. See also Bhaskar and Gupta, 'India's missing girls'.

[29] Beltrán Tapia and Gallego-Martínez, 'Where are the missing girls?', p. 120.

[30] Ibid., p. 123. Relying on the estimation exercise using life expectancy carried out by Klasen and Wink, 'Turning point', yields a similar figure (99.4).

0–1 and 1–5 years) recorded in the 1860 Spanish population census were 104.7 and 103.8, respectively, thus pointing to some sort of unexplained excess female mortality.[31] Moreover, these figures are not specific to 1860: the infant sex ratios in 1857 and 1877 were actually very similar, at 104.2 and 104.7, respectively.[32]

Notwithstanding that average sex ratios remained relatively high in nineteenth-century Spain, some regions exhibited even more extreme figures. Relying on an extremely rich dataset at the district level, this article analyses regional variation within Spain in 1860 in order to examine what lies behind the unbalanced sex ratios, so we can have a better assessment of the underlying motives driving the observed gender discrimination. The 1860 population census provides a detailed picture of the situation in Spanish districts (*partidos judiciales*) when unbalanced sex ratios were at their highest.[33] In fact, 54 districts (out of 471 observations) have infant sex ratios above 115.

Although some of these districts are relatively small and therefore subject to high levels of random variation, it is very unlikely that most of these results occurred by chance. In the absence of prenatal sex selection, a child's sex is basically a random process that conforms to the binomial distribution. While infant sex ratios tend to be quite homogeneous at the societal level, due to the law of large numbers, sex ratios at smaller levels of aggregation show more random variation. Although this is the case at the district level, the probability of obtaining such extreme values by chance alone is extremely low.

Figure 1 depicts the observed sex ratios and the size of the population behind those numbers. Given the statistical properties of sex ratios, instead of the male-to-female ratio, it is more appropriate to express them as proportions—that is, as the number of boys divided by the total number of boys and girls.[34] As the 95 per cent confidence intervals of a hypothetical distribution of a gender-neutral infant sex ratio revolving around parity testify, a large part of the extreme sex ratios observed falls beyond that threshold, thus indicating that some sort of gender discrimination was occurring.

Assuming a gender-neutral sex ratio close to parity ($p = 0.5$), 43 districts have infant sex ratios that are significantly higher than would be expected. Given that this is a two-tailed test at the 95 per cent significance level, we would expect that only around 12 districts would fall beyond that threshold (2.5 per cent of 471 observations). Even considering a more conservative scenario, which assumes a gender-neutral sex ratio of 102 ($p = 0.505$), 29 districts would have statistically significant extreme values.[35]

[31] Junta General de Estadística, *Censo.*

[32] Although not perfectly comparable, the Floridablanca Census (1787) also reports a sex ratio of 104.5 at age 0–7; ibid., p. 121.

[33] Infant sex ratios declined to 103.3 in 1887 and 102.3 in 1900 and then initiated an increasing trend throughout the twentieth century. For more details, see ibid., p. 120.

[34] Wilson and Hardy, 'Statistical analysis' p. 48; Brian and Jaisson, *Descent*, pp 228–9. The distribution of the proportion of boys depends on the expected proportion of males (p) and the sample size (n), where the variance equals $[p(1- p)]/n$. The male/female ratio is not well suited for statistical analysis because such ratios are asymmetrical and undefined. See Wilson and Hardy, 'Statistical analysis', p. 52.

[35] Online app. S1 reports the actual probabilities of obtaining such extreme values for all the districts with infant sex ratios above 115. Online app. S2 shows that child sex ratios (aged 1–5) are also heavily skewed to the right. Given that we do not have a reliable estimation of a gender-neutral sex ratio at older ages, the same graph cannot be depicted for the 6–10 age-group.

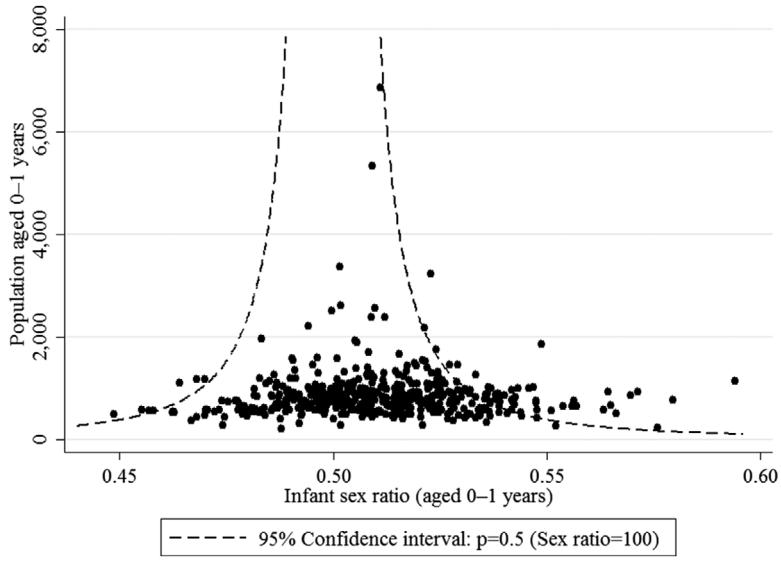

Figure 1. *District infant sex ratio: proportion of boys, 1860 (by size of the target group)*
Note: The dotted lines represent the confidence intervals of a hypothetical distribution of gender-neutral sex ratios around parity (100 boys per hundred of girls; p = 0.5) relative to district size. See section II for more details.
Source: Junta General de Estadística, *Censo*.

It is worth stressing that the fact that we also observe relatively lower infant sex ratios is not necessarily related to the absence of discriminatory impulses. It could be the case that although the incentives to discriminate were present, especially in unfavourable contexts, these impulses might be counterbalanced by social and cultural practices that may not be present in other contexts. Nonetheless, the random component of our variable of interest decreases as districts grow in size and, as a result, the observed sex ratio tends to get closer to its hypothetical true value. The next section will therefore take this feature of the data into account when carrying out the econometric analysis.

In order to assess whether gender discrimination is also visible during childhood, we have also collected data on later age cohorts: 1–5 and 6–10 years. These older cohorts include many more individuals than the infant population and their distributions thus contain much less random noise. Likewise, given that the female survival advantage continued throughout childhood, child sex ratios should be smaller than infant sex ratios. As expected, average sex ratios decreased with age: from 104.7 for the 0–1 age group to 103.8 and 102.6 in the older age groups, respectively. Figure 2 maps regional sex ratios for these three age groups. Unsurprisingly, finding geographical patterns is not straightforward due to the high levels of random variation characterizing these ratios in small districts. However, the following sections manage to unveil some interesting patterns.

III

Given that high sex ratios suggest gender discrimination early in life, a behaviour that was more common in some regions, we are now interested in analysing the

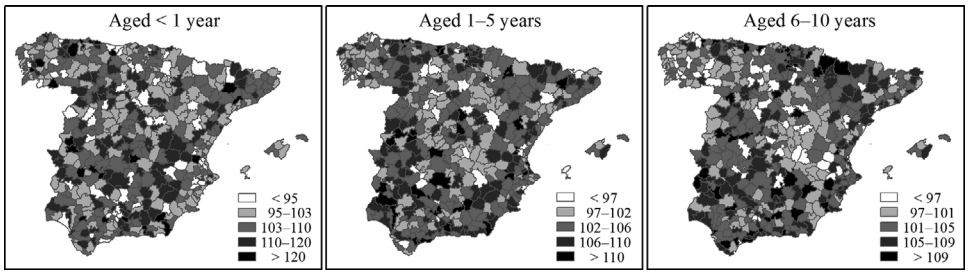

Figure 2. *Infant and child sex ratios (by district and age-group), 1860*
Source: As for fig. 1.

large variation in infant sex ratios within Spain so as to explore the factors behind this variation.[36] In this regard, instead of trying to estimate causal relationships, our aim is to unveil general patterns behind the data, test existing hypotheses, and set an agenda for further research.[37]

Apart from pure random variability, the regional disparities in the sex ratios may arise from multiple causes, including factors that are not related to the presence of a gender bias. A different disease environment, for instance, may harm girls more than boys and may therefore explain the unbalanced sex ratios observed in Spain and other countries in southern Europe.[38] In order to shed more light on these issues, we identify economic, social, and environmental factors that may theoretically explain this variability and then regress district sex ratios on that set of variables:

$$SR_i = \alpha + \beta_1 ECON_i + \beta_2 SOCIAL_i + \beta_3 ENVIRON_i + \varepsilon_i \quad (1)$$

The dependent variable is the sex ratio (at ages 0–1, 1–5, and 6–10) in each district measured as a proportion. Following the literature on gender discrimination in infancy and childhood (as explained below), the independent variables aim to capture the economic, social, and environmental factors characterizing those areas. Taking into account all these factors simultaneously allows us to isolate the ones that are directly associated with unbalanced sex ratios. It is also worth stressing that identifying patterns from this type of data is particularly challenging. Not only is our dependent variable extremely noisy, but discriminatory practices are likely to have taken place only in the lowest socio-economic groups, thus making those practices less visible when using information based on the whole population.

Economic context

Economic conditions directly affected the nutritional status of the population during this period. A considerable portion of the population lived close to

[36] Although primarily interested in a composite measure of the long-term evolution of gender equality, Dilli et al., 'Achieving gender equality', also perform a cross-country analysis of the factors affecting sex ratios at age 0–5. They find that gender discrimination diminishes with higher incomes and increases in countries where stem family systems are more widespread.
[37] Gelman and Imbens, 'Why ask why?'.
[38] Beltrán Tapia and Gallego-Martínez, 'Where are the missing girls?'.

subsistence levels and their situation clearly worsened in times of economic stress. Apart from potential starvation, food deprivation reduces the capacity to survive infectious diseases. Indeed, malnourishment as a factor contributing to mortality rates in Spain did not disappear until the twentieth century.[39] Due to the female biological survival advantage in utero and during infancy, sex ratios should theoretically be lower under severe economic conditions.[40] If, on the contrary, economic deprivation shows a positive relationship with the prevalence of boys, it would be evidence of potential gender discrimination, in the form of either female infanticide or the neglect of young girls, especially in terms of nutritional deprivation and susceptibility to infection. It may be the case that both effects offset each other, so the lack of a clear relationship between these variables and the sex ratio might be (cautiously) interpreted as weak evidence of gender bias.

Economic conditions are measured using population density and level of urbanization. The existence of large agro-towns, especially in southern Spain, also necessitates that we take into account the importance of the manufacturing sector. Given that social standing also influences nutritional status and living conditions and, subsequently, mortality rates in infancy and childhood, economic conditions are further captured using the extent of access to land and the incidence of poverty.[41] Likewise, demographic pressures, and the resource constraints involved, are proxied by the number of children (aged 0–10) per woman aged 20–40. Infant mortality increases with family size,[42] which would again tend to reduce the male-to-female ratio, but, in the presence of gender bias, competition for scarce resources could result in higher female mortality.

Several authors have also emphasized the presence of waged-labour opportunities for women as a crucial factor mitigating gender discrimination within the household.[43] In order to include this variable, we have computed the fraction of the working-age female population (aged 16–40) that undertook paid jobs.[44] Although not remunerated, cattle rearing also constituted an important source of working opportunities for women in rural areas,[45] so the importance of these activities has also been considered by including a measure of livestock density.[46] Furthermore, our variable of interest could be influenced by the proximity of urban markets and administrative and political entities, so distance to major cities and to provincial capitals is therefore included in the model. Including distance

[39] Reher and Sanz-Gimeno, 'Childhood mortality patterns'.

[40] Beltrán Tapia and Gallego-Martínez, 'Where are the missing girls?'.

[41] While access to land is measured as the fraction of landowners and tenants in the total agricultural population, the poverty ratio is computed as the percentage of destitute individuals in the active population. The 1860 population census refers to the poor as '*pobres de solemnidad*'.

[42] Reher and Sanz-Gimeno, 'Childhood mortality patterns', pp. 30–2.

[43] Klasen and Wink, 'Turning point'; Qian, 'Missing women'.

[44] The vast majority of women working outside the household fell within that age range. See Ferrer, 'Notas'; Camps, 'Transitions'. Nevertheless, extending the definition of female working age to older ages does not change the results reported here. The 1860 population census enumerates women working as schoolteachers, industrialists, artisans, factory workers, and servants.

[45] Humphries, 'Enclosure'.

[46] According to Voigtländer and Voth, '"West"', women in pre-industrial societies had comparative advantage in animal husbandry. Alesina, Giuliano, and Nunn, 'Origins', argue that gender norms are more unequal in societies where agriculture has been traditionally based on the use of the plough. Rearing cattle stands here in contrast to farming generally. Obviously women in families devoted to other kinds of agriculture also contributed, but their role was, or at least was perceived as, secondary.

to provincial capitals is especially relevant because most foundling hospitals were based in these capitals.[47]

Social context

Social and cultural factors are also likely to have played an important role, either fostering or mitigating gender discrimination. In this regard, the potential role of different family systems is unclear. Strong family ties have been related to lower levels of female labour force participation and more traditional views on gender roles.[48] Family systems are also linked to inheritance rules and dowry systems, which are widely linked to skewed sex ratios in South and East Asia.[49] Analysing the Spanish case, Tur-Prats argues that co-residence with her mother-in-law increased the wife's contribution to farming work in traditional peasant families, which in turn has resulted in lower levels of intimate-partner violence nowadays.[50] Although nuclear households with partible inheritance prevailed, stem families were quite numerous in parts of northern Spain. In the latter, the heir brings a spouse to the family house where different generations then co-reside and, although inheritance rules prioritized sons, daughters could become the heiress in cases where there were no male alternatives. Following Reher, the complexity of family arrangements has been measured as the number of female adults (aged 26–80) per household.[51]

Due to the explicit prohibition of infanticide, the role of the Catholic Church appears to have been very important in explaining European families' behaviour regarding this practice.[52] Nevertheless, it is also true that religious authorities favoured a strong patriarchal system, so its effect on gender discrimination may not be altogether clear. Although Catholicism was the only religion present in Spain during this period, the level of identification with Catholic teachings could vary across regions. The importance of the Church has been proxied by computing the percentage of priests in the total active population.[53] In addition, the educational level of the population, especially of mothers, has also been associated with the incidence of excess female mortality.[54] Increased education helps to overcome entrenched cultural practices, so literacy levels have also been included in the model.

Environmental factors

Climatic factors have been put forward to explain part of the variation in sex ratios at birth.[55] Many diseases affect males and females differently, so sex ratios can

[47] Pérez Moreda, *La infancia abandonada*.
[48] Alesina and Giulano, 'Power'.
[49] Das Gupta et al., 'Son preference'.
[50] Tur-Prats, 'Family types'. Likewise, Valverde, 'Illegitimacy', argues that extended families provided an environment that reduced the incidence of child abandonment in the Basque country during the pre-industrial period.
[51] Reher, *Perspectives*.
[52] Lynch, 'European women'.
[53] This variable has been shown to be positively related to literacy levels during this period; Beltrán Tapia and Martínez-Galarraga, 'Inequality and education'.
[54] Klasen and Wink, 'Turning point'.
[55] Warm temperatures are apparently related to higher sex ratios in Scandinavian countries. See Catalano, Bruckner, and Smith, 'Ambient temperature'; Helle, Helama, and Lertola, 'Evolutionary ecology'.

also reflect these differences.[56] Anderson and Ray argue that, in India, China, and Sub-Saharan Africa, infectious, parasitic, and respiratory diseases account for a significant fraction of excess female deaths in childhood.[57] It is well known that infant mortality in southern Europe is highest in summer due to the incidence of digestive diseases.[58] Regional variations in mortality rates are indeed pronounced within Spain and partly reflect diverse climatic conditions,[59] so it may therefore be possible that high sex ratios are not caused by gender discrimination, but by a different disease incidence and/or composition by region.

In order to try to capture these environmental factors, measures of temperature and rainfall, together with altitude, ruggedness, and distance to the coast, are included in the analysis and treated as controls.[60] Given the potential existence of further unobserved heterogeneity, it is important to also test the model including provincial fixed-effects. Online appendices S3 and S4 outline how all the variables employed here have been constructed and report summary statistics.

IV

Equation 1 is estimated using a generalized linear model (GLM) that fits maximum-likelihood methods assuming a binomial distribution and using a logit function. This approach has two advantages over a conventional linear model estimated using ordinary least squares.[61] On the one hand, this specification, by transforming sex ratios into logits, deals adequately with bounded data such as sex ratios. On the other hand, this method also allows the accuracy of each observation to be taken into account—that is, the sample size underlying each sex ratio.

The results of regressing infant sex ratios on the set of variables explained above are reported in table 1. While column 1 presents the baseline specification, column 2 extends the model by adding provincial fixed effects. The number of infants belonging to this age cohort might be relatively small in some districts, thus potentially introducing high levels of random variability in the dependent variable. Although, as discussed above, our specification takes into account the sample size from which our observed sex ratios arise, columns 3 and 4 repeat the exercise, restricting the sample to those districts in which the population aged 0–1 is larger than 500 individuals in order to address this concern. Columns 5 and 6 test the robustness of our results further by excluding those districts with extreme sex ratios (above 120). As expected, the model performs better (with lower deviance from a

[56] Waldron, *Too young*.
[57] Anderson and Ray, 'Missing women'.
[58] Wrigley, Davies, Oeppen, and Schofield, *English population*.
[59] Cussó and Nicolau, 'La mortalidad'; Dopico and Reher, *El declive*; Ramiro-Fariñas and Sanz-Gimeno, 'Structural change'.
[60] Coastal areas and northern Spain, which were colder and more humid, enjoyed lower mortality rates during the period of analysis. See Dopico and Reher, *El declive*; Ramiro-Fariñas and Sanz-Gimeno, 'Structural changes'. Moderate temperatures in summer and abundant rainfall limited infectious diseases (especially digestive diseases that were so important for infant mortality). The interior of the Peninsula constituted a region of extremely high mortality (see Dopico, 'Regional mortality tables'; Pérez Moreda, *Las crisis*), so distance to the coast has also been included as a control. Although already partly captured by livestock density, the variable ruggedness may also further capture the relative importance of agriculture and cattle rearing. Controlling for environmental variables also helps to alleviate potential bias arising from other unobserved factors that are related to climate/geography, such as agricultural productivity or the type of diet available.
[61] Wilson and Hardy, 'Statistical analysis'.

Table 1. *Determinants of the infant sex ratio, 1860*

	Dependent variable: sex ratio, proportion					
	Whole sample		*Population aged 0–1 > 500*		*Excluding Infant sex ratio > 120*	
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Population density (ln)	−0.11**	−0.15***	−0.10**	−0.13***	−0.09**	−0.13***
	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)	(0.05)
Urbanization	−0.14**	−0.24***	−0.08	−0.18***	−0.09	−0.17**
	(0.07)	(0.08)	(0.07)	(0.07)	(0.07)	(0.07)
Manufacturing	0.37	0.72	0.20	0.38	0.07	0.27
	(0.50)	(0.47)	(0.44)	(0.41)	(0.46)	(0.42)
Poverty ratio	0.44	−0.22	0.85	0.50	0.49	0.02
	(0.70)	(0.72)	(0.63)	(0.67)	(0.63)	(0.66)
Land access	0.08	0.11	0.03	0.01	0.00	−0.03
	(0.17)	(0.18)	(0.15)	(0.17)	(0.16)	(0.18)
Family size	−0.18	−0.13	−0.09	0.10	−0.10	0.04
	(0.11)	(0.15)	(0.10)	(0.14)	(0.11)	(0.16)
Women's waged labour	−1.03***	−0.69**	−0.92***	−0.59**	−0.86***	−0.55**
	(0.32)	(0.27)	(0.30)	(0.25)	(0.32)	(0.25)
Livestock density	0.00	−0.00	0.00	−0.00	0.00	−0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Family type	−0.56**	−0.18	−0.53**	−0.06	−0.55**	−0.08
	(0.23)	(0.27)	(0.21)	(0.24)	(0.23)	(0.26)
Priests	−0.08	0.03	−0.13*	−0.02	−0.12	−0.02
	(0.09)	(0.09)	(0.08)	(0.08)	(0.08)	(0.08)
Literacy	0.07	−0.90*	−0.28	−0.59	−0.37	−0.60
	(0.40)	(0.46)	(0.35)	(0.44)	(0.36)	(0.46)
Distance to major cities (ln)	0.08***	0.07	0.09***	0.08**	0.09***	0.08*
	(0.03)	(0.04)	(0.02)	(0.04)	(0.02)	(0.04)
Distance to provincial capital (ln)	0.10***	0.08***	0.07***	0.06**	0.07***	0.06***
	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)
Geography/climate	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	No	Yes	No	Yes	No	Yes
Observations	469	469	420	420	401	401
Deviance	26.64	19.12	17.38	12.58	16.49	11.88

Notes: Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$. Parameters estimated by maximum likelihood assuming a binomial distribution and using a logit function. For simplicity, the intercept is not reported.
Source: Junta General de Estadística, *Censo*.

theoretical model that would fit the data perfectly) when we restrict the analysis to the larger districts and the outliers are excluded.[62] More importantly, the results remain qualitatively unchanged regardless of the specification employed.

It appears that living in urban and densely populated areas is associated with lower infant sex ratios. Although these effects may point to the idea that economic dynamism reduced gender discrimination, we should bear in mind that, due to the female survival advantage, the higher overall infant mortality provoked by those contexts should have negatively affected boys more than girls, thus pushing infant sex ratios down.[63] It is therefore difficult to disentangle these two influences.

[62] As the target population becomes larger, sex ratios approximate their *true* value, thus reducing the random component. Also, as the decrease in the deviance evidences, relevant regional variations are captured by the inclusion of province dummies.

[63] See Beltrán Tapia and Gallego-Martínez, 'Where are the missing girls?'. In 1900, while life expectancy at birth only reached 29.5 years in the provincial capitals, it was about 36 years in rural areas; Dopico and Reher, *El*

The coefficients on distance to the provincial capital and other major cities also suggest that proximity to urban centres reduced infant sex ratios. Again, it may be the case that, rather than facilitating differential female mistreatment, more rural areas enjoyed better access to food, as well as a lower incidence of respiratory and digestive diseases, thus improving boys' survival chances. Ramiro-Fariñas, however, argues that rural–urban differences in mortality rates are mostly explained by the presence of public institutions such as hospitals, prisons, and mental and foundling hospitals.[64] If urban and densely populated areas did then not suffer worse living conditions, the negative coefficient shown by these variables would suggest that their economic dynamism alleviated gender discrimination early in life.

Other economic and social factors clearly mitigated female infanticide and/or the mortal neglect of newborn girls. On the one hand, the existence of waged labour opportunities for women, by enhancing women's economic and social status, seems to have improved the value of girls within the household. On the other hand, the prevalence of extended families in which different generations of women co-habited also had a beneficial effect on girls' survival.[65] The effect of these two variables gives support for a behavioural explanation of excess female mortality in the first year of life.

The rest of the variables included in the model do not show any clear association with the infant sex ratio. Although the coefficient on literacy levels shows the negative expected sign, its effect is not statistically significant. The lack of a more visible relationship might be explained when we bear in mind that literacy levels in Spain were extremely low during this period. In this regard, it is likely that discriminatory practices mostly occurred among lower socio-economic groups, where illiteracy was widespread, so it is possible that we do not have enough variation in our data. Likewise, considering the low level of knowledge about the spread of diseases at that time, education could perhaps do little to improve child survival. Even in the early twentieth century, women were apparently relatively slow to modify their habits regarding infant feeding and care.[66] Similarly, infant sex ratios seem to be lower in regions with a greater presence of priests. Although religious beliefs or the moral control exerted by the Catholic Church may have mitigated female infanticide and/or the mortal neglect of newborn girls, their effect is not statistically significant.

The intrinsically random nature of the dependent variable may mask the effect of some of the variables analysed here. Also, as noted above, it is plausible that some counteracting effects offset the potential impact of gender discrimination. For instance, poverty and the number of children within the household constrain family resources and are thus likely to trigger discrimination against girls. However, economic deprivation, by negatively affecting overall health conditions, tends to

declive, p. 14. Higher population densities, together with lacking or deficient water and sewage systems, resulted in deplorable living conditions and facilitated the spread of diseases. The presence of orphanages and hospitals also contributed to raising mortality rates in cities. In particular, the effect of respiratory diseases on childhood mortality was greater in towns than in the countryside. The urban penalty would only disappear in the 1920s. On these issues, see Dopico and Reher, *El declive*; Ramiro-Fariñas and Sanz-Gimeno, 'Structural changes'; Reher, 'Search'.

[64] Ramiro-Fariñas, 'Mortality'.

[65] Although the effect of *family type* becomes statistically insignificant when provincial dummies are included, this is because most of the variation in this variable takes place at that level of aggregation.

[66] Reher and Sanz-Gimeno, 'Childhood mortality patterns', p. 27.

take a greater toll on boys.[67] Likewise, the positive influence that the existence of livestock may have had on the perceived value of women, consequently reducing sex ratios, might have been counterbalanced by the resources they provided to families, especially meat and dairy products, thus improving their net nutritional intake, which in turn would have reduced the excess male mortality that is present both in utero and during the first months of life.

Although female under-reporting was not the main factor behind the extreme infant and child sex ratios observed in nineteenth-century Spain,[68] it should be stressed that under-reporting may affect our results if the poor enumeration of girls was somewhat related to the variables analysed here. However, although this problem may be an issue during the first year of life, the concern is less plausible at older ages. Nevertheless, in order to address this issue and test the robustness of our results, we repeat the exercise, this time employing sex ratios during childhood. Table 2 presents the results of this analysis: while columns 1 to 4 focus on children aged 1–5, columns 5 to 8 focus on those aged 6–10.[69] By controlling for the sex ratio in the previous age cohort, the specifications reported in columns 3–4 and 7–8 shed light on whether differential treatment continued throughout childhood.

These results not only strongly confirm our previous findings but also provide evidence that the same factors behind the variation in infant sex ratios continued to affect sex-specific mortality patterns at older ages.[70] Although anecdotal evidence is scarce, a report from a doctor in Tineo, a small town in north-western Spain, suggests that girls continued to be treated differently as they grew older: deaths from anaemia and pulmonary tuberculosis, resulting from nutritional deprivation and unhygienic conditions, affected female children disproportionately.[71] In addition to discrimination in the allocation of resources within the household, Horrell and Oxley also point to the 'double burden', arising from working both outside and within the domestic sphere, that girls usually suffered without receiving nutritional compensation.[72] In circumstances of economic deprivation, excess labour would reduce net nutritional status and increase girls' susceptibility to diseases. Sarasúa indeed claims that young girls in Spain were supposed to help their mothers with

[67] In this regard, using micro-level data from a medium-sized industrial town in Catalonia, Ramon-Muñoz and Ramon-Muñoz, 'Sibship size', show that, *c.* 1860, boys from single-child families were much taller than those raised in larger families.

[68] Although parents may have failed to report girls early in life, they should be visible in the census when older. The evolution of sex ratios at older ages (1–5 years and 6–10 years) mimic that of infant sex ratios, thus providing evidence that the poor enumeration of girls cannot account for the extreme sex ratios reported here; Beltrán Tapia and Gallego-Martínez, 'Where are the missing girls?', p. 121. Similarly, although pointing to significant under-registration in the early population censuses, Reher, 'En los umbrales', p. 254, does not find that under-reporting varied by sex. On these issues, see also Reher and Valero Lobo, *Fuentes*; and Gozálvez Pérez and Martín-Serrano Rodríguez, 'El Censo'.

[69] Given that the groups object of study are large enough, it is not necessary now to restrict the analysis to the larger districts: except one district whose sex ratio at age 6–10 is based on 879 children, all the remaining districts contain more than 1,000 children in each age cohort. In any case, repetition of the exercise restricting the sample to the larger districts, as in tab. 1, does not alter the results reported here.

[70] Although our results are robust regardless of the age-group employed, we cannot completely rule out the possibility that female under-registration may also partly explain biased sex ratios in rural areas far from administrative centres.

[71] Borderías et al., 'Gender inequalities', p. 183.

[72] Horrell and Oxley, 'Gender bias'.

Table 2. *Determinants of the childhood sex ratio, 1860*

	Dependent variable							
	Sex ratio, ages 1–5				*Sex ratio, ages 6–10*			
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Population density (ln)	−0.14***	−0.16***	−0.14***	−0.16***	−0.11**	−0.13***	−0.10**	−0.12**
	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)	(0.05)
Urbanization	−0.21**	−0.24***	−0.19**	−0.24***	−0.16**	−0.24***	−0.16**	−0.24***
	(0.08)	(0.07)	(0.08)	(0.07)	(0.08)	(0.07)	(0.08)	(0.07)
Manufacturing	0.32	0.32	0.39	0.34	0.03	0.30	0.01	0.28
	(0.46)	(0.40)	(0.46)	(0.40)	(0.48)	(0.39)	(0.47)	(0.38)
Poverty ratio	−0.61	−0.59	−0.51	−0.57	−1.14*	−0.97	−1.21*	−1.06
	(0.65)	(0.66)	(0.64)	(0.66)	(0.67)	(0.67)	(0.67)	(0.67)
Land access	0.07	0.19	0.07	0.20	0.04	0.17	0.05	0.19
	(0.16)	(0.17)	(0.16)	(0.17)	(0.16)	(0.17)	(0.16)	(0.17)
Family size	−0.20*	−0.16	−0.19	−0.16	−0.12	−0.10	−0.13	−0.12
	(0.12)	(0.15)	(0.12)	(0.15)	(0.12)	(0.14)	(0.12)	(0.14)
Women's waged labour	−0.92***	−0.58**	−0.96***	−0.58**	−0.91***	−0.60**	−0.91***	−0.61**
	(0.30)	(0.26)	(0.30)	(0.26)	(0.32)	(0.25)	(0.32)	(0.25)
Livestock density	0.01	0.00	0.01	0.00	0.00	−0.00	0.00	−0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Family type	−0.80***	−0.39	−0.79***	−0.38	−0.77***	−0.42*	−0.79***	−0.45*
	(0.21)	(0.25)	(0.21)	(0.24)	(0.22)	(0.25)	(0.22)	(0.25)
Priests	−0.03	0.01	−0.05	0.00	−0.03	0.00	−0.02	0.01
	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)
Literacy	0.38	−0.59	0.39	−0.58	0.13	−0.66	0.12	−0.65
	(0.38)	(0.46)	(0.38)	(0.46)	(0.39)	(0.45)	(0.39)	(0.46)
Distance to major cities (ln)	0.06**	0.06	0.06**	0.07	0.04	0.07*	0.04	0.07*
	(0.03)	(0.04)	(0.03)	(0.04)	(0.03)	(0.04)	(0.03)	(0.04)
Distance to provincial capital (ln)	0.09***	0.07***	0.09***	0.07***	0.09***	0.07***	0.09***	0.07***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Sex ratio, ages 0–1			−1.41*	−0.65				
			(0.77)	(0.65)				
Sex ratio, ages 1–5							2.08	3.06**
							(1.64)	(1.28)
Geography/climate	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	No	Yes	No	Yes	No	Yes	No	Yes
Observations	469	469	469	469	469	469	469	469
Deviance	25.70	17.68	25.52	17.65	26.35	17.40	26.25	17.19

Notes: As for tab. 1.
Source: As for tab. 1.

housekeeping and taking care of their siblings, an obligation that was not shared by their brothers.[73]

The lack of association between infant sex ratios and those at ages 1–5 is nonetheless puzzling. This may indicate that some sort of female under-reporting occurred during the first year of life. Alternatively, we should note that the mortality crises that took place between 1855 and 1858 did influence the older age cohorts but barely affected infant sex ratios in 1860. Given that boys were more vulnerable to adverse conditions, if the incidence of famines and epidemics was higher in areas that for other reasons had more boys (that is, less dense, less urbanized areas), those

[73] Sarasúa, 'El acceso'.

initially high sex ratios would have been mitigated by the subsequent excess male mortality.

In any case, we should be cautious when comparing the coefficients on the sex ratios of the different age groups because, apart from the differential incidence of the 1850s mortality crises, other factors are likely to have affected them in complex ways. The physiological survival advantage of girls, for instance, decreases as children get older. Likewise, due to the protection afforded by breastfeeding, the closer infants are to birth, the less effect economic conditions have on mortality.[74] Once older children are weaned, their sensitivity to economic conditions increases, due to insufficient hygiene in infant feeding practices.[75] Furthermore, sex-specific migration is less probable at younger ages. In this regard, sex ratios increase as we move further from major cities but this pattern is less clear for older children (aged 6–10). Although evidence of migratory patterns for children is lacking, it is plausible that, given the risks associated with migration, boys were more likely to move, or be sent away, than girls.

Lastly, in order to test the robustness of our results further, we have re-estimated our model using infant and child sex ratios in 1887 as dependent variables. Although the quality of the 1860 population census has been favourably considered by the literature,[76] Reher argues that the 1887 population census constituted a great improvement on the previous ones.[77] The information provided at the district level by the latter, however, is not as rich as in the 1860 census and it is thus not possible to capture important features of our previous analysis, such as land access inequality, poverty rates, or livestock density. Therefore, we have tested whether our previous results, which refer to variables measured from the 1860 population census, hold when linked to sex ratios extracted from the 1887 population census.[78] As shown in online appendix S5, the results of this exercise provide further evidence that our previous analysis is not biased by potential problems of that census and confirm the picture described above.

V

Discriminatory practices resulting in excess female mortality early in life constituted a veiled feature of Spanish society during an important part of the nineteenth century. The results presented here indicate that, in a strongly patriarchal society, certain economic and social conditions were likely to trigger gender discrimination against newborn and/or young girls during the period studied here. On the one hand, the existence of wage labour opportunities for women and the prevalence of extended families in which different generations of women cohabited clearly mitigated discriminatory practices. On the other hand, excess female mortality in infancy appears to have been higher in rural areas. Although the relative value of girls in these contexts was probably lower than in denser and more urbanized areas which therefore may have promoted female discrimination, it is also possible that

[74] Reher and Sanz-Gimeno, 'Mortality and economic development', p. 139.
[75] It should be noted that older children may be better able to resist certain forms of infection than very young infants; ibid., p. 140.
[76] Gozálvez Pérez and Martín-Serrano Rodríguez, 'El Censo', p. 336.
[77] Reher, *España a la luz del censo de 1887*, p. 33.
[78] We are grateful to David Reher for kindly sharing his data.

healthier conditions resulting from better access to nutrition and less exposure to the disease environment prevalent in densely populated areas contributed to reduce boys' excess mortality and thus increase male-to-female infant and child sex ratios.

The findings reported here are nonetheless tentative. Given the random nature of the subject of study, research on sex ratios should rely on very large samples.[79] Although our smallest districts never contain less than 200 children aged 0–1, this sample size may not be large enough, as the high volatility of this variable shows. However, we have employed statistical techniques that mitigate this concern. The analysis of the older age cohorts, whose sex ratios are based on much larger populations, also helps alleviate this problem. Similarly, female under-enumeration might also affect infant sex ratios. This issue, however, is unlikely to be present in older age groups and our results persist when these cohorts are analysed. Likewise, although we have tried to cover as many variables as possible, it is still possible that we may have omitted some important factors. Thus we cannot claim that there is a direct causal link between the variables examined here and unbalanced sex ratios.

Rather than being the result of female infanticide or the mistreatment of young girls, the excess female mortality discussed here was probably due to an unequal allocation of resources within the household. In high-mortality environments, slight discrimination in the way young girls were fed or treated when ill, as well as in the amount of work with which they were entrusted, could easily lead to higher morbidity and mortality rates. Given their very nature, these subtle forms of gender discrimination are difficult to detect. The type of discriminatory practices suggested here probably only occurred among certain segments of the population, so aggregate data are likely to conceal relevant information. Uncovering patterns of gender discrimination in pre-industrial Europe thus requires putting certain populations under a magnifying glass. The evidence examined is nevertheless highly suggestive and should serve as a basis for further research. We hope that this modest step will lead other scholars to investigate this hitherto neglected topic.

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[79] Gelman and Weakliem, 'Of beauty'.

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Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

S1. Statistical significance of districts with sex ratios above 115 boys per hundred girls
S2. District child sex ratio (ages 1–5): proportion of boys, 1860 (by size of the target group)
S3. Description of the variables employed
S4. Summary statistics
S5. Determinants of the infant sex ratio, 1887