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RESEARCH ARTICLE

"For Better, for Worse": The Role of Siblings in Survival and Biological Well-Being in Rural Aragón (Spain) in the Twentieth Century

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Abstract

This article examines the evolution of the role played by the number and gender of siblings in the survival and biological well-being of individuals in rural Spain during the twentieth century. Our aim is to test how two fundamental theories – the cooperative breeding hypotheis and the resource dilution hypothesis – about how the number of siblings affect the individual come together in this area of study during a period of economic, health, and social transformation. We used a sample of 19,331 individuals born between 1900 and 1979 from 14 rural villages, for whom data on sibling count and various family and environmental variables are available. Using these data, we ran several statistical models to discover the effects of siblings on survival. In addition, we studied the long-term effect of siblings on height using height data from 2,783 male conscripts. Our results show that the number of siblings positively influenced survival, either through the cooperation of older siblings in the care of their younger brothers and sisters or through parents exhibiting higher offspring survival abilities. However, increased reproductive success may come with a disadvantage. The biological well-being, as measured by height, of male conscripts was significantly lower among individuals with more siblings in the early decades of the study. Conversely, in the later decades, the negative relationship between sibship size and height was not statistically significant when the number of living siblings was fewer than five.

Keywords: Siblings; height; cooperative breeding; resource dilution; rural Spain

Introduction

There is intense debate in the demographic literature as to whether sibship size matters, (Black et al. 2005; Booth and Kee 2008; Chu et al. 2007; Downey 1995, 2001; Dribe et al. 2012; Li et al. 2008; Marteleto and de Souza 2012; Öberg 2017;

Shavit et al. 1991; Steelman et al. 2002; Yu et al. 2012;) especially in relation to whether the existence of a large number of siblings (particularly older siblings) had positive, negative, or neutral effects on the survival and well-being of new siblings (Brody 2004; Riswick and Engelen 2018; Riswick and Hsieh 2020; Sear and Coall 2011; Sear and Mace 2008; White and Hughes 2017). While some studies find a clear positive effect of older siblings (Beise 2005; Crognier et al. 2001, 2002; Sear et al. 2002; Sear 2008), others find no effect (Hill and Hurtado 1996). The results could also reflect the region studied, the period, the data, and the methodology (Riswick and Engelen 2018; Sear and Mace 2008). Due to the wide variety of results obtained, several theories have been developed, although none have been fully confirmed.

In this article, we will focus on two theories that are linked to two different stages of the life cycle. The first is the cooperative breeding theory, which focuses on whether older siblings had a positive effect on the survival and well-being of their younger siblings through their contributions to the rearing of these siblings (Burkart et al. 2009; Kramer 2015; Pen and Weissing 2000). As mentioned, several studies have found positive results compatible with the cooperative breeding hypothesis (Beise 2005; Crognier et al. 2001, 2002; Sear et al. 2000, 2002; Sear 2008, all find a positive effect of older siblings).

The second is the resource dilution hypothesis predicts a negative association between sibship size and child outcomes in the long term (Öberg 2017). The logical explanation would be that the limited resources available in a family must be shared among all of the infants. Therefore, the greater the number of children, the fewer resources for each sibling, which would have a direct negative impact on them.

Some studies support the resource dilution theory (in the nineteenth century: Bras et al. 2010; Kok et al. 2011; Van Bavel et al. 2011; In the twentieth century: Bailey et al. 2016; Blau and Duncan 1978; Hatton and Martin 2010; Roberts and Warren 2017; Steelman at al. 2002; Stradford et al. 2017; in the twenty-first century: De Keyser and Van Rossem 2017).

We will approach the resource dilution hypothesis through the stature of male conscripts at 21 years of age (age at which young Spaniards entered military service since the 1850s, with some exceptions).[1] According to Öberg (2017:160), "one important reason why information on height is useful when we investigate resource dilution is that this framework assumes that the parental resources are important for the development of the child (. . .) This is the most important strength of using data on height to study how children are affected by their sibship size." Some studies found no associations between sibship size and adult heights (Beekink and Kok 2017; Ramon-Muñoz and Ramon-Muñoz 2017).

In any case, we should not forget that both theories can be complementary, producing effects in different directions that manifest themselves to a greater or lesser extent depending on family, cultural, and environmental characteristics.

[1]During the analyzed period, the age at conscriptions varied over time. During the period 1856–85, age at military conscription was 20 years old; during 1885 (second call-up)–99 19 years; between 1901 and 1905 it was 20; onwards it was 21 years old. Thus, we have standardized the average height to the age of 21 years. For it, we have used the same strategy of Ramon-Muñoz (2011) based on the calculated 50th percentile of the three age groups (19, 20, and 21 years), adding 1.2 cm to the height of 19 years and 0.4 cm to the height of 20 years. Our results are similar to those obtained in other Spanish regions.

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Therefore, this article helps us to study these theories from the approaches we have available in a specific period and geographic space, giving greater diversity to the international literature.

Recently, this literature has been enriched with contributions from different and varied approaches. Gibbs et al. (2016) suggest that, in addition to the resources that parents provide to their children, societal institutions can also contribute resources to families that can vary over time and place, potentially leading to different results. Fox et al. (2017) demonstrated that ecological context and cultural differences are decisive factors in sibling behavior and its positive or negative effects on sibling survival in historical populations. Sear and Mace (2008) and Riswick and Engelen (2018) showed the diversity of situations that have occurred in recent centuries in the West, where geographic and temporal space has proven to be a determining factor of the first level. Riswick (2018) demonstrated that the quantity and gender of siblings exerted a significant influence on childhood mortality rates in the Netherlands during the nineteenth and early twentieth centuries, but had less significance in relation to infant mortality. The presence of siblings of the same sex negatively affected the survival prospects of boys in the Netherlands, indicating that, beyond the first year of life, boys faced heightened competition from their siblings. Quanjer and Kok (2019) introduce the concept of a rise of the breadwinner model contributed to the increase in Dutch statures as suggested by Knibbe (2007) and De Vries (2008). They do not include the female work participation in their regressions because women's labor was underreported, as is the case of Spain (Borderías 2013; López-Antón and Tantiñà 2020; Sarasúa 2019). Other authors (Kalmijn and Van de Werfhorst 2016; Kok et al. 2011; Park 2008) analyze how cultural factors have influenced different countries in the same way. De Keyser and Van Rossem (2017) study birth weight and length. Their results are relevant because they reveal that these factors do not depend on the conditions of life after birth. Among the latest works to be published under the approach of conditional research model, it is worth highlighting those carried out by Pujadas-Mora et al. (2018) for Barcelona in the sixteenth and seventeenth centuries; Paiva et al. (2018) for Ribeira Seca in the Azores in the nineteenth century; Park et al. (2018) for Korean in the mid-twentieth century; and the one made by Riswick (2018) for the Netherlands in the nineteenth century.

Therefore, the objective of this article is to examine the role of siblings at the time of birth and throughout childhood and adolescence, within a new geographical (inland rural Spain) and temporal (twentieth century) context. Hence, we have not only studied the effect of the number of siblings on survival at different ages (neonatal, infant, and childhood mortality) but also the longer-term effect on height. The scarcity of articles on the historical influence of relatives on the welfare of new children in Spain (among the few that exist, we can highlight Reher and González-Quiñones 2003) and particularly in rural Spain make this article an interesting contribution to the historical demography of southern Europe. Moreover, our results differ from some of the results obtained for other parts of the country, especially in relation to resource dilution theory (Ramón-Muñoz and Ramón-Muñoz 2017).

Due to the availability of quality data on families (during the twentieth century the parish archives contain regularly added notes with extra information on all

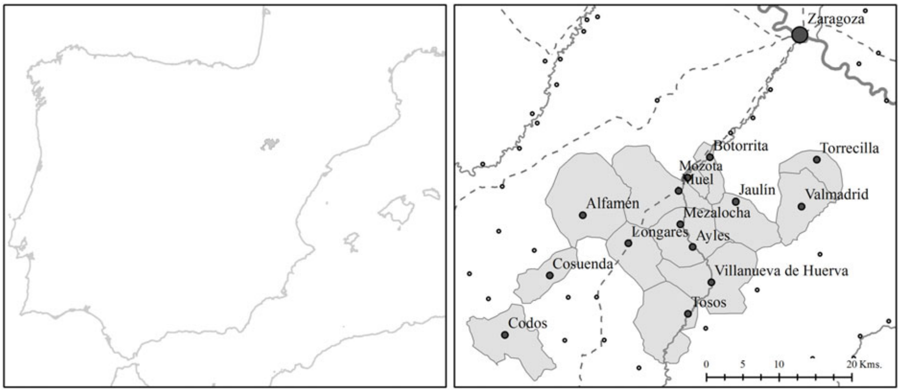

Figure 1. Area of study: Middle Huerva (Aragón, Spain).
Source: Own elaboration.

individual members even if they out-migrated), and given our special interest in the process of economic and social modernization in Spain (Germán 2012), we have focused on individuals born in the twentieth century. The first four decades (first sub-period) were largely characterized by a high number of children per family. The fertility transition began in the early twentieth century in the study area, but the largest decline in marital fertility occurred in 1930s (Marco-Gracia 2018). The second sub-period, after the Spanish Civil War (1936–39) until the 1970s, was a period of transformation that began with the harsh post-war period and continued with high rates of economic growth, especially after the 1959 Stabilization Plan (Lissen and Díaz 2015). This second sub-period was characterized by low marital fertility and an average family size that was clearly lower than in previous decades.

Study area and family ties

This research focuses on a rural area in Aragon, in northeast Spain. The border of the area is 19 km away from Zaragoza, the regional capital. The 14 villages of the study area are as follows: Alfamén, Aylés, Botorrita, Codos, Cosuenda, Jaulín, Longares, Mezalocha, Mozota, Muel, Torrecilla de Valmadrid, Tosos, Valmadrid, and Villanueva de Huerva (see Fig. 1). The area had a population of approximately 8,200 in 1900, 10,700 in 1940, and 5,600 in 1980. These municipalities were selected because they form a homogeneous area dedicated to agriculture (cereals and vineyards), and cattle raising (sheep grazing), and because of the type of families residing in them (mostly nuclear households). Until the mid-twentieth century, 80 percent of the male working population was engaged in the agricultural sector (Marco-Gracia 2018; Marco-Gracia and López-Antón, 2023). Although the sources do not provide data for female labor, the women were likely employed in the agricultural and/or rural manufacturing at the same time (López-Antón 2021).

Of the individuals engaged in the primary sector, mainly in agriculture, approximately 35–40 percent were smallholders, while a further 40–45 percent were semi-landless and landless. Native shepherds accounted for approximately 7–8 percent, decreasing from the late nineteenth century onwards. In the secondary sector, small artisans such as blacksmiths, carpenters, etc., represented approximately 7 percent. The remaining 5–6 percent corresponded to the tertiary sector in occupations such as doctors, veterinarians, teachers, military men, and others. Most of the population enjoyed living standards close to subsistence levels.

All agriculture in the area was conducted on non-irrigated land, except for the fields near the Huerva River. In the mid-20th century, the "Las Torcas" Reservoir was constructed in the municipality of Tosos. Notably, from the 1970s onward, the development of irrigation infrastructure significantly boosted agricultural production (Marco-Gracia 2011; Marco-Gracia and González-Esteban 2024a, 2024b). Throughout the twentieth century, with economic modernization, the number of day laborers needed in the agrarian tasks in the study areas declined, so some of these workers had to migrate to the cities or become low-skilled workers in factories and other activities. The rural areas of the Ebro Valley specialized in agricultural products for the Spanish domestic market, such as cereals, sugar beet, and sheep meat (Germán 2012; Pinilla and Ayuda 2009). The Spanish Civil War constituted a strong negative shock to Aragon's economic modernization, from which the area of study did not recover and which may have favored rural-urban migration (Silvestre 2005).

According to David Reher's research (2004), family ties, particularly in Southern Europe, are strong throughout an individual's life. They have historically been robust, especially in rural areas with small villages where a high percentage of inhabitants share genetic bonds. Within these families with strong ties, the relationship between siblings has been particularly close during youth, with mutual support existing throughout the period they remain in the family home and beyond (Izquieta 1996; Voorpostel et al. 2007). Therefore, we can expect that in the study area, siblings would rejoice at the birth of new members and contribute to their care (Izquieta 1996).

During the long period studied in this article (1900–79), Spain experienced a significant improvement in its living, health, and nutritional conditions (Cussó et al. 2018; Nicolau 2005; Pérez-Moreda et al. 2015), which can be observed in the upward evolution of height in our study area (see Fig. 2). This also leads us to consider that the effect of siblings on newborn survival would have changed over time. On the one hand, childhood mortality had declined as a result of improvements in medicine and hygiene (Mokyr 2002: 179–87; Nathanson 2007: 25–46; Preston and Haines, 1991: 6–11). Therefore, we might expect the effect of siblings to diminish over time as medical advances became more important. On the other hand, it is precisely the increase in health and hygiene knowledge that could intensify the effect of older siblings. In other words, as knowledge increases, care and the application of this knowledge become more decisive (Griffith, 1926; Szreter, 1988, 1993, 2002). We are therefore looking at a variable context of 80 years in which medical knowledge and resources have increased, but in which the impact of siblings on low mortality may also have increased.

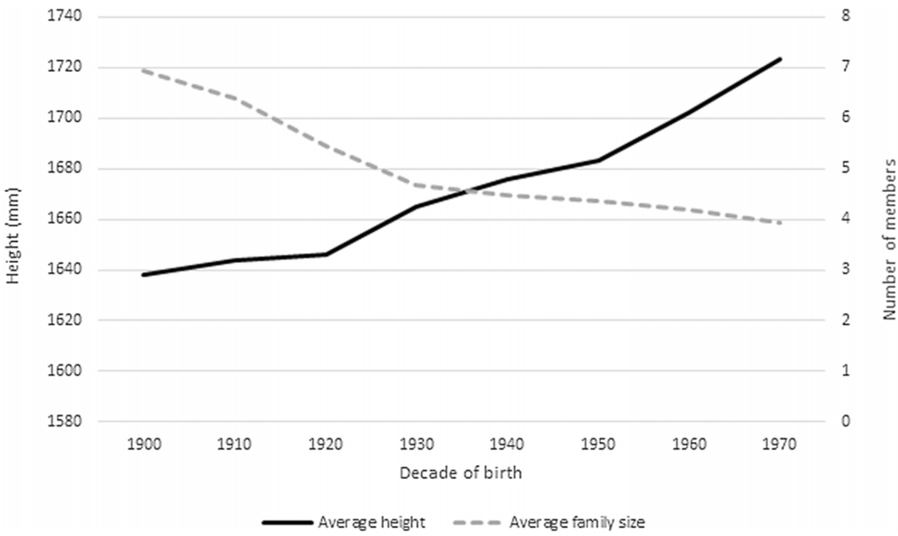

Figure 2. Evolution of average height and average family size in the area of study, 20th century.
Source: AMHDB.

Data and methods

This article focuses only on complete families for which we have information indicating that both parents lived beyond 49 years of age (therefore, they completed their fertile cycle) and vital information about all their children, providing high-quality data on siblings for the twentieth century. For this, we need to know at least one piece of information about all children after baptism, usually their participation in a census or a subsequent event (either marriage or death). We lose from our analysis individuals who migrated out of the study area without having reappeared in parish records or censuses in adulthood, discarding families with individuals to whom we cannot know what happened.[2]

In Table 1, we have described the distribution by periods (birth cohorts 1900–39 vs. birth cohorts 1940–79) and categories of the different variables used in this article. First, as a key variable, we identified the *number of siblings* alive of each individual. We have categorized the number of siblings into three groups: (1) having 0 or 1 sibling; (2) 2–4 siblings; and (3) 5 or more siblings. It should be noted that due to the demographic transition, family size varied over time. In the 1900–1910s, approximately 40 percent of the individuals studied formed part of a family of five or more members, while in the 1960–70s only 10 percent belonged to this category. We know the time of birth of all individuals in the families studied and their time of death (or whether they reached adulthood). Then, we have entered into the Cox proportional hazards models for all the siblings during the observation period. That

[2]As mentioned above, in the twentieth century it was common for the parish priest to record any other event of the individual (whether it was confirmation, marriage, or death) in addition to the baptismal certificate, so in more than 95 percent of the cases we can follow individuals into adulthood.

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Table 1. Description of the variables

		1900–39			1940–79		
		No observations	%	Mean	No observations	%	Mean
Number of living siblings	0–1	6,449	45.3		2,627	47.2	
	2–4	5,439	38.2		2,216	39.8	
	5 or more	2,349	16.5		724	13.0	
Sex	Female	6,914	48.6		2,687	48.3	
	Male	7,323	51.4		2,880	51.7	
Father's occupation	Farmer	4,513	31.7		1,626	29.2	
	Low-skilled	4,940	34.7		1,904	34.2	
	Artisan	2,264	15.9		640	11.5	
	Upper class	1,552	10.9		1,130	20.3	
	Other	968	6.8		267	4.8	
Age group of the mother	<20	812	5.7		145	2.6	
	20–24	4,954	34.8		2,388	42.9	
	25–29	4,684	32.9		1,770	31.8	
	30–34	3,317	23.3		1,147	20.6	
	35 or more	470	3.3		117	2.1	
Average height (males)		1,636		164.4 cm	761		168.2 cm
Average marital fertility		14237		2.99 children	5,567		2.22 children
Mortality rate (per 1,000 individuals)		14237		218.5	5,567		63.2

Source: Parish and municipal registers.

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is, if we are studying survival between 1 and 4 years, and an individual crossing the first year threshold had two siblings, one survived to adulthood and one died two years later (and no new sibling was born), the individual is assigned to the 2–4 sibling group until the death of the sibling, on which day that individual is assigned to the 0–1 sibling group (that day went from having two living siblings to only one). In the case of OLS models, we consider the total number of siblings born (since the variable cannot vary over time in these models).

In addition to the *number of siblings*, in Table 4 we have replicated the basic models by taking into account only the *number of brothers* or the *number of sisters*. In this case, due to the lower number of combinations, the categories have been re-established as follows: (1) No siblings of that gender; (2) 1 or 2 brothers (or sisters); and (3) 3 or more brothers (or sisters).

The *sex* of the baby has been introduced as an independent variable, given that in a society that has historically shown a preference for sons, there may be differences in survival depending on the gender of the newborn (as can be seen in previous studies, e.g., Marco-Gracia and Beltrán Tapia 2021; Riswick 2018). The *socioeconomic category of the father* (family of origin) is also considered a variable of great interest because of the possible existence of differences according to the socio-economic group. We know that families with higher incomes had better possibilities to buy food in times of short-term economic crises and this favored their survival regardless of family size (Bengtsson et al. 2004). This variable is distributed into five categories: (1) Farmers, (2) Low-skilled employees, (3) Artisans, (4) Upper class (mainly doctors, teachers, veterinarians, and other high-skilled occupations), and (5) Others or unknown. Several studies have shown a relationship between the father's occupation and offspring survival or height (Ayuda and Puche 2014; Bengtsson et al. 2004; Cámara et al. 2019; Martínez-Carrión and Puche-Gil 2009; Pamuk 1985; Quiroga 2003). In addition, the *village* variable allows us to control for the geographical context of each village. The presence of rivers, main communication routes, or the type of crop could influence the arrival of diseases or crop failure.

At the household level, we have introduced *Age group of the mother,* as the age of the mother can influence both her life experience and income (Marco-Gracia et al. 2024). To control for factors linked to the demographic transition and, especially, to its temporal evolution, we have included two basic variables: *average marital fertility* and *childhood mortality rate* in the whole study area, in both cases by decade of birth – that is, for the whole study area without differentiating by locality so as not to conflict with the *village* variable.

With respect to the model for the determinants of height in relation to the number of siblings (Table 5), in addition to the general variables, two other variables have been taken into account: *literacy* as a proxy for parental investment in children, especially in the first decades of the twentieth century, and *appeals for exemption* from military service, which contain the physical and social allegations if they were accepted by the court as legitimate.

As previously mentioned, we employed two types of models for the statistical analysis. To assess the probabilities of mortality within specific age ranges (0–28 days, 1–12 months, and 1–4 years), we utilized Cox proportional hazards (PH) regression, with age serving as the time scale instead of the individual observation time, while adjusting for left truncation at a0. This selection was motivated by the consideration that using a model based on age at the event occurrence, rather than one based on individual observation time, might be preferable if age exerts a greater influence on the event of interest (in this case, death) than observation time (Kleinbaum and Klein 2012; Korn et al. 1997).

$$h(a,\ X) = h_0(a_0) exp\ exp \left[\sum \beta_i X_i\right]$$

where $h(a,\ X)$ is the hazard of death; $h_0(a_0)$ is the baseline hazard – that is, the hazard function for an individual having on all covariates the value 0.

i = [SES of the father, village, ... n], with n being the number of variables
i = [SES, birth date, village of residence, ... n], with n being the number of variables
$\beta_i = [\beta_{SES}\ \beta_{birth}\ \ldots\ \beta_n]$, where β_i corresponds to the value "beta" of variable i.

For our analysis, we employed the counting process format, which involves tracking each day throughout the initial five years of life. This format accommodates multiple lines of data for each individual, dividing their total at-risk follow-up time into smaller intervals. This approach is advisable when age at follow-up time is the outcome variable, as opposed to the time of follow-up, and it facilitates the incorporation of time-dependent variables such as the mother's age group (Kleinbaum and Klein 2012).

In the case of the relationship between height and the number of siblings, considering the continuous nature of the dependent variable (individual's height) and our interest in studying the determinants of height, we employed ordinary least squares (OLS) linear regressions with heteroskedasticity-robust estimation, as utilized in several previous studies with similar characteristics (Ayuda and Puche-Gil 2014; Cámara et al. 2019; Martínez-Carrión and Puche-Gil 2009; Marco-Gracia and Puche, 2021). All models can be denoted as follows:

$$\mathrm{Height_i} = \beta_1 * \mathrm{X_{1i}} + \beta_2 * \mathrm{X_{2i}} + \beta_3 * \mathrm{X_{3i}} + \cdots + \varepsilon$$

where height is the dependent variable for an individual i, X_n denotes the independent variables (number of living siblings, father's occupation, literacy, appeals for exemption, age group of the mother, average marital fertility, mortality rate, and village), and ε is the error term.

The effect of siblings on the survival of new offspring

To further explore the role of the number of older living siblings in the survival of the new children in Table 2, we have performed six Cox PH regression models divided into two groups according to sub-periods (1900–1939 and 1940–79). Therefore, we have performed two for neonatal mortality (having died before 28 days of life), two for infant mortality (first year of life), and two for childhood mortality (five years of life). In these models, we control for both the individual's lifespan and the time of death or survival, as well as the siblings' ages, dropping the analysis at the time of their death (if that had happened). Therefore, all siblings

Table 2. Cox regression estimates of dying before 28 days, 1 year, or 5 years, birth cohorts sub-period 1900–39 and sub-period 1940–79

		1900–39			1940–79		
		<28 days	1–12 months	1–5 years	<28 days	1–12 months	1–5 years
		(1)	(2)	(3)	(4)	(5)	(6)
Number of living siblings	0–1	1	1	1	1	1	1
	2–4	0.990*	0.991*	0.993	0.997	0.993	0.994
	5 or more	0.879***	0.882***	0.759***	0.798*	0.673**	0.750**
Sex	Female	1	1	1	1	1	1
	Male	0.779***	0.961	1.129**	0.588**	0.910	1.005
Father's occupation	Farmer	1	1	1	1	1	1
	Low-skilled	0.998	0.997	0.998	0.998	1.009	1.010
	Artisan	1.012	1.012	1.020	0.977	0.990	0.985
	Upper class	0.950	0.952	0.990	1.005	1.008	1.009
	Other	0.999	0.998	0.999	0.986	0.985	0.989
Age group of the mother	<20	1.120**	1.221*	1.095	1.224**	1.321*	1.111
	20–24	1.052	1.092	1.085	1.044	1.100	1.112
	25–29	1	1	1	1	1	1
	30-34	0.895	0.901	0.944	0.924	0.960	0.965
	35 or more	1.212*	1.242***	1.190*	1.454*	1.550*	1.369
Average marital fertility	(continuous variable)	0.999	1.001	1.001	0.998	0.998	0.997
Mortality rate	(continuous v.)	1.002***	1.002**	1.002***	1.001**	1.001*	1.001**

(*Continued*)

Table 2. (*Continued*)

	1900–39			1940–79		
	<28 days	1–12 months	1–5 years	<28 days	1–12 months	1–5 years
	(1)	(2)	(3)	(4)	(5)	(6)
Village fixed	YES	YES	YES	YES	YES	YES
No individuals	13,968	12,707	11,446	5,297	5,185	5,023
Events	660	1,261	1,901	112	162	55

Source: Parish and municipal registers.
Notes: se denotes robust standard error. *Statistical significance at 10% level, **at 5% level, ***at 1% level. See Table A1 of the Appendix in Supplementary material for the results with *Number of living siblings* as continuous variable.

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cohabiting with the subject under study are taken into account regardless of their sex.

The results of Table 2 in relation to the number of living siblings provide us with a very interesting and significant insight. In all cases (neonatal, infant, and childhood mortality), the number of siblings favored the survival of new siblings. In fact, each additional sibling increases the chances of survival of the new family member by around 1 percent to 5 percent, with this effect being especially important in the first year of the baby's life. The data are shown in Table A1 of the Appendix in Supplementary material where the number of siblings is included as a continuous variable. These results are compatible with the existing literature (Beise 2005; Crognier et al. 2001, 2002; Sear et al. 2000, 2002; Sear 2008). In relation to sub-periods, while for those born in the sub-period 1900–1939, all categories of the number of siblings are significant for all age groups (except 2–4 siblings for 1–5 years group), reducing the chances of dying until approximately 10 percent; for those born in the sub-period 1940–79, only having a very high number of siblings (five or more) is significant, and only for infant and childhood mortality.

Regarding the rest of the variables in the model, the father's occupation does not seem to have influenced (at least not significantly) the children's survival. We must take into account the fact that the rural area of the study did not have a very high social class with marked social differences. Periods of higher childhood mortality increased the probability of death but with small ratios (around 1 percent). The specific situation of the child (health, family, etc.) seems to have been more important than the general situation.

In Table 3, we have replicated the complete models of Table 2 by age group and sub-period, but distinguishing between whether the new child was a boy or a girl. We cannot forget that we are in an area that, until well into the twentieth century, was characterized by a strong preference for boys (Beltrán Tapia and Marco-Gracia 2022). Therefore, we will focus mainly on the differences found between this new analysis (Table 3) and the results found for the population as a whole (Table 2).

Regarding our key variable, the number of older siblings and the results are highly significant. For girls, the increase in the number of siblings is significantly related in all cases, with an increase in the likelihoods of survival for girls over 1 month (of more than 10 percent). However, the effect is particularly strong in the case of boys. Perhaps as a consequence of their greater weakness at birth, they may have required greater care. Therefore, in the case of boys this variable is significant in all cases when there was a high number of siblings (five or more). However, when there were fewer than four siblings, we did not find significant results for boys (although the confidence interval is close to 90 percent), but we did observe the characteristic gradient that we already noted in Table 2. Regarding the rest of the variables in Table 3, we found that there were no significant changes in terms of gender in the variables of father's occupation or parity.

In Table 4, we have replicated the full model of Table 2, but only taking into account the presence of brothers or sisters (separately), to see if the gender of the siblings was important in survival. Again, we will highlight only the results that differ from Table 2.

With respect to the number of siblings, we find that for both sisters and brothers the significant categories are the same (having three or more siblings of that gender

Table 3. Cox regression estimates of dying before 28 days, 1 year, or 5 years according to gender, birth cohorts sub-period 1900–39 and sub-period 1940–79

		Birth cohorts 1900–39					
		Females			Males		
		<28 days	1–12 months	1–5 years	<28 days	1–12 months	1–5 years
		(1)	(2)	(3)	(4)	(5)	(6)
Number of living siblings	0–1	1	1	1	1	1	1
	2–4	0.995	0.905***	0.976*	0.955	0.960	1.002
	5 or more	0.980	0.890**	0.776***	0.887**	0.888**	0.912*
Age group of the mother	<20	1.088**	1.173*	1.109	1.356**	1.387*	1.229
	20–24	1.012	1.010	1.025	1.110	1.154	1.134
	25–29	1	1	1	1	1	1
	30–34	0.906	0.909	0.955	0.944	0.987	0.980
	35 or more	1.189*	1.202***	1.195*	1.676*	1.560*	1.404
Mortality rate	(continuous v.)	1.001***	1.001***	1.002***	1.001***	1.001***	1.001***
Control – Father's occupation		YES	YES	YES	YES	YES	YES
Control Av. marital fertility		YES	YES	YES	YES	YES	YES
Village fixed		YES	YES	YES	YES	YES	YES
No individuals		6,914	6,638	6,066	7,323	6,939	6,250
Events		276	572	939	384	689	962

(*Continued*)

Table 3. (*Continued*)

		Birth cohorts 1940–79					
		Females			Males		
		<28 days	1–12 months	1–5 years	<28 days	1–12 months	1–5 years
		(7)	(8)	(9)	(10)	(11)	(12)
Number of living siblings	0–1	1	1	1	1	1	1
	2–4	0.996	0.974*	0.932**	0.991	0.986	1.001
	5 or more	0.966	0.799*	0.782**	0.765*	0.900**	0.871**
Age group of the mother	<20	1.187	1.209	1.115	1.310	1.339	1.267
	20–24	1.102	1.115	1.098	1.187	1.100	1.129
	25–29	1	1	1	1	1	1
	30–34	0.945	0.979	0.971	0.987	0.995	0.990
	35 or more	1,373*	1.488**	1.311**	1,507*	1.609**	1.501**
Mortality rate	(continuous v.)	1.001**	1.001**	1.001***	1.001*	1.001*	1.001**
Control – Father's occupation		YES	YES	YES	YES	YES	YES
Control Av. marital fertility		YES	YES	YES	YES	YES	YES
Village fixed		YES	YES	YES	YES	YES	YES
No individuals		2,687	2,631	2,559	2,880	2,824	2,734
Events		56	72	78	56	90	89

Source: Parish and municipal registers.
Notes: se denotes robust standard error. *Statistical significance at 10% level, **at 5% level, ***at 1% level. See Table A2 of the Appendix in Supplementary material for the results with Number of *living siblings* as continuous variable.

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Table 4. Cox regression estimates of dying before 28 days, 1 year, or 5 years in relation to number of brothers/sisters, birth cohorts sub-period 1900–39 and sub-period 1940–79

		Birth cohorts 1900–39					
		Sisters			Brothers		
		<28 days	1–12 months	1–5 years	<28 days	1–12 months	1–5 years
		(1)	(2)	(3)	(4)	(5)	(6)
Number of living siblings	0	1	1	1	1	1	1
	1–2	0.999	0.996	0.999	0.997	0.993	0.999
	3 or more	0.960	0.988*	0.984**	0.989	0.983**	0.979**
Age group of the mother	<20	1.124**	1.222*	1.097	1.222**	1.319*	1.110
	20–24	1.056	1.092	1.087	1.041	1.098	1.110
	25–29	1	1	1	1	1	1
	30–34	0.899	0.905	0.948	0.922	0.957	0.961
	35 or more	1.214*	1.246***	1.191*	1,450*	1.549*	1.363
Mortality rate	(continuous v.)	1.002***	1.002***	1.003***	1.002***	1.002***	1.003***
Control – Father's occupation		YES	YES	YES	YES	YES	YES
Control Av. marital fertility		YES	YES	YES	YES	YES	YES
Village fixed		YES	YES	YES	YES	YES	YES
No individuals		13,968	12,707	11,446	13,968	12,707	11,446
Events		660	1,261	1,901	660	1,261	1,901

(*Continued*)

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Table 4. (*Continued*)

		Birth cohorts 1940–79					
		Sisters			Brothers		
		<28 days	1–12 months	1–5 years	<28 days	1–12 months	1–5 years
		(7)	(8)	(9)	(10)	(11)	(12)
Number of living siblings	0	1	1	1	1	1	1
	1–2	0.999	0.996	0.998	0.997	0.992	0.999
	3 or more	0.977	0.987**	0.984**	0.990	0.986***	0.981***
Age group of the mother	<20	1.227**	1.325*	1.113	1.222**	1.320*	1.108
	20–24	1.043	1.107	1.116	1.043	1.100	1.109
	25–29	1	1	1	1	1	1
	30–34	0.928	0.963	0.968	0.921	0.958	0.963
	35 or more	1,459*	1.551*	1.371	1,453*	1.549*	1.368
Mortality rate	(continuous v.)	1.001***	1.004***	1.004***	1.001***	1.004***	1.004***
Control – Father's occupation		YES	YES	YES	YES	YES	YES
Control Av. marital fertility		YES	YES	YES	YES	YES	YES
Village fixed		YES	YES	YES	YES	YES	YES
No individuals		5,297	5,185	5,023	5,297	5,185	5,023
Events		112	162	55	112	162	55

Source: Parish and municipal registers.
Notes: se denotes robust standard error. *Statistical significance at 10% level, **at 5% level, ***at 1% level. See Table A3 of the Appendix in Supplementary material for the results with *Number of living siblings* as continuous variable.

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in the case of infant and childhood mortality). However, the coefficients change. The effect of the brothers seems to have almost double the effect of the sisters in most of the coefficients. As we will discuss below, perhaps because of their greater importance in the family budget, they were able to contribute some supplementary income given that labor opportunities and wages in rural Spain were much more favorable for males (Borderías and López-Guallar 2003; Borderías and Muñoz-Abeledo 2018). With regard to the rest of the variables, we did not find significant changes with respect to Table 1 in relation to the gender of the siblings.

The effect of siblings on biological well-being

In Table 5, we have performed an analysis of the determinants of stature (in millimeters) in relation to the number of siblings, dividing the study into the two sub-periods (1900–1939 and 1940–79). For each sub-period, we have performed three types of models. The first type studies only the relationship between height and the number of siblings (models 1 and 4). The second type of model includes number of living siblings, father's occupation, literacy, appeals of exemption, and age group of the mother (models 2 and 5), while the last type includes all the variables (models 3 and 6). The aim of Table 5 is to analyze whether, as might be expected, there was an evolution of the influence of the factors studied conditioned by the economic, social, and health and hygiene improvements experienced by Spanish society throughout the twentieth century.

Both models 1 and 4 show that number of siblings was correlated during the study period with shorter height. In all cases, a high presence of siblings (five or more) is associated with more than one cm of height penalty. Family resources were limited and had to be shared between more children. In relation to periods, the results in Table 5 confirm that there was an important difference between children born in the first four decades of the twentieth century and those born later. Thus, among individuals born in the sub-period 1900–1939, the number of siblings was of great importance since, according to our results, as this number increased, so did the negative effect on the height of male conscripts. In contrast, in the analysis for those born in the period 1940–79, the variable regarding the number of siblings loses significance.

Table 5 shows that paternal socioeconomic status (SES) was also important in determining the height of individuals. This also constitutes further evidence of the fact that, due to the low living standards prevailing in rural Spain for most of the twentieth century, paternal income conditioned food availability, and the biological well-being of children. After controlling for the childhood mortality rate, our results indicate that children of a low-skilled employee (the lowest social class in our study) were more than one centimeter shorter than the children of farmers. Similar results have already been found for other studies on the determinants of height in Spain (Ayuda and Puche-Gil 2014; Cámara et al. 2019; Martínez-Carrión and Puche-Gil 2009; Quiroga 2003). On the other hand, in all models for the period 1900–1939, being the child of an upper-class individual was significantly related to a height of around 3 centimeters taller than that of the farmers' children. In any case, according

Table 5. Determinants of height, birth cohorts sub-period 1900–39 and sub-period 1940–79

		1900–39			1940–79		
		(1)	(2)	(3)	(4)	(5)	(6)
Number of living siblings	0–1 (ref.)						
	2–4	−8.203*** (5.42)	−5.018** (4.00)	−6.411** (4.00)	−6.414 (8.62)	−5.731 (8.66)	−4.988 (8.57)
	5 or more	−16.932** (5.23)	−12.582** (6.85)	−11.587* (6.84)	−12.656** (9.20)	−11.741** (9.32)	−7.669** (9.27)
Father's occupation	Farmer (ref.)						
	Low-skilled employee		−5.024 (4.36)	−4.985 (4.36)		−11.498* (6.09)	−11.502* (6.02)
	Artisan		3.592 (9.19)	3.179 (9.18)		−3.544 (10.00)	−3.931 (9.88)
	Upper class		33.197* (18.73)	33.780* (18.70)		11.860 (11.20)	8.112 (11.17)
	Other or unknown		−8.954* (4.73)	−7.963* (4.74)		3.037 (8.63)	0.400 (8.55)
Literacy	Illiterate (ref.)						
	Literate		7.521 (6.63)	4.424 (6.72)		8.351 (44.63)	8.095 (44.12)
	Unknown		−9.663 (12.49)	−6.574 (12.54)		–	–
Appeals for exemption	No appeal (fit to serve) (ref.)						
	Physical appeals		−19.918*** (4.89)	−19.082*** (4.90)		−1.686 (7.70)	−1.571 (7.63)

(*Continued*)

Table 5. (*Continued*)

		1900–39			1940–79		
		(1)	(2)	(3)	(4)	(5)	(6)
	Social appeals		21.098** (8.83)	20.123* (8.83)		−35.276 (23.98)	−29.052 (23.79)
Age group of the mother	<20		10.865 (6.98)	11.511* (6.99)		−6.604 (15.76)	−1.320 (15.70)
	20–24		0.633 (3.51)	0.602 (3.52)		4.920 (6.39)	2.260 (6.38)
	25–29 (ref.)						
	30–34		−4.467 (5.41)	−3.690 (5.38)		13.690 (11.90)	15.110 (11.86)
	35 or more		12.590 (9.30)	11.287 (9.29)		−11.629 (16.42)	−12.411 (16.34)
Average Marital Fertility	(continuous variable)			−7.980 (8.50)			−6.539 (29.91)
Mortality rate	(continuous variable)			−0.032 (0.08)			−0.521*** (0.15)
	Intercept	1663.25*** (12.09)	1673.35*** (15.99)	1705.24*** (20.73)	1690.52*** (8.14)	1660.75*** (48.96)	1547.76*** (75.10)
Control Village		NO	YES	YES	NO	YES	YES
	Sample size	1,636	1,636	1,636	761	761	761
	Adjusted R2	0.005	0.099	0.103	0.003	0.069	0.093

Source: Parish and municipal registers.

Notes: OLS estimates; *se* denotes robust standard error. *Statistical significance at 10% level, **at 5% level, ***at 1% level. See Table A4 of the Appendix in Supplementary material for the results with *Number of living siblings* as a continuous variable. *Number of living siblings* denotes those that survived to the five first years of life and could compete for the available resources.

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to the coefficients of Table 5, at least in the area under study, the general explanatory power of SES might be less pronounced than other Spanish studies have assumed.

As shown in previous studies (Ayuda and Puche-Gil 2014; Puche and Marco-Gracia 2024), the health of individuals at 21 years proves to be a very important variable in understanding the height of individuals. Thus, individuals with severe physical health problems were, on average, approximately 1.5 centimeters shorter than the rest but only in the first sub-period. Finally, while average marital fertility does not appear significant in any period, the rate of childhood mortality per decade is highly significant and negative in the second sub-period, showing that each 1 percent increase is associated with a drop in height of approximately 5 millimeters. Therefore, the fall in infant mortality is related to taller height possibly as a result of the general hygienic-sanitary improvements that facilitated a reduction in childhood mortality during the twentieth century (Cussó et al. 2018; Nicolau 2005; Pérez-Moreda et al. 2015), as well as improvements within the families themselves that facilitated the adequate growth of individuals (Marco-Gracia and Esteban-González 2021).

Discussion

We first looked at the effect of siblings on the survival of new siblings to understand whether there is a positive and significant relationship between the two factors (Beise 2005; Crognier et al. 2001, 2002; Sear et al. 2000, 2002; Sear 2008). Our results could be showing that the number of siblings had a great influence on the likelihoods of survival of newborns, especially for those born in the first decades of the twentieth century (1900–1930s). Survival of newborns can be increased by 10 percent (and even 20 percent) if there is a large number of siblings. The connection between these variables could be established in two ways. On the one hand, older brothers and sisters could have contributed to the care of infants and young children with simple tasks. We should not forget that until well into the second half of the twentieth century, Spanish rural families had little access to modern innovations (such as household appliances or disposable products). In fact, in many localities they did not even have running water until the last quarter of the century. On the other hand, a high number of siblings can also be related to a higher reproductive success of these families (whether due to biological, behavioral, or even hygienic practices). Despite having controlled for socioeconomic groups in the models, within each group there may still be differences. Therefore, our results show that a high presence of siblings favors newborn survival as has been found in other contexts in the West countries (Beise 2005; Crognier et al. 2001, 2002; Sear et al. 2000, 2002; Sear 2008).

Traditional gender roles in Spain (and across the Western world) have dictated that women take on household and childcare responsibilities, while men assume an active role in the labor market, often being the primary breadwinners (López-Sáez et al., 2008). Hence, we examined the effect while differentiating between brothers and sisters in Table 4. Our findings indicate that, overall, the effect of brothers is more significant than that of sisters. Beyond caregiving, this is possibly due to boys' rapid access to the labor market through small agricultural tasks, often starting as

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early as age 7, which allowed them to contribute to the family budget, benefiting the entire household. In a context of low living standards and significant pressure on the limited family budget, the support provided by brothers could have been crucial in enhancing the quantity and quality of the family's diet (Borderías and López-Guallar, 2003; Borderías and Muñoz-Abeledo, 2018).

With respect to the gender of the newborns, our results suggest that in the area of study the availability of brothers and sisters was more important for girls. This could be because boys, relatively weaker at birth, have a mortality that cannot be easily remedied with care, while girls, slightly stronger, have a better chance of survival with proper care (Vaupel et al. 1979; Wisser y Vaupel 2014). In addition, we should not lose sight of the fact that this was an area with a strong preference for boys (Beltrán Tapia and Gállego-Martínez 2017, 2020; Marco-Gracia and Beltrán Tapia 2021). Until the beginning of the twentieth century, there was still an excess mortality of girls as a result of differential treatment during childhood (Beltrán Tapia and Marco-Gracia 2022). Therefore, we have a combination of historical discrimination against girls and greater weakness at birth in boys.

Especially noteworthy are the results relating to height, which appear to indicate that all members of the nuclear household exerted a significant influence on the height of other household members in the study area. We can observe that a large number of siblings is associated with a smaller stature, which would be partially associated with a dilution of resources indicative of low standards of living (Öberg 2017). Therefore, the resource dilution hypothesis would be fulfilled (even if only partially), especially during the first sub-period. This would contrast with the results found for the Netherlands and Catalonia previously (Beekink and Kok 2017; Pujadas-Mora et al. 2018; Ramon-Muñoz and Ramon-Muñoz 2017). However, we should not forget that our study area is located in a particularly poor area where small changes in the budget could be decisive in biological well-being and even survival. Previous studies for the same study area, although not focused on the same hypothesis, have also pointed out that in a situation of such constrained budgets, the number of feeders to be fed is related to the final height reached (Marco-Gracia and López-Antón 2021; Marco-Gracia, 2023, 2024), but also with other factors such as hygiene (Marco-Gracia and González-Esteban 2021).

If we look at the results from Table A4 in the Appendix in Supplementary material – which examines the effect of the number of siblings (as a continuous variable) on height – we find a remarkable finding. With the simplest regression models (models 1 and 4, which only relate the number of siblings as a continuous variable to height), the coefficient value (−1.299 vs. −1.376) appears to be more pronounced in the second period than in the first. However, the intensity changes when controlling for the other variables. Additionally, we must be aware that the average number of siblings born among individuals for whom we know their height in the second sub-period (3.7) is lower than that of the first sub-period (6.3). Very large families (with more than six children) were occasional in the first sub-period and exceptional in the second sub-period. This could have an impact on the coefficients.

We should also consider that the poorest families were likely to have more children and, therefore, were most negatively affected in terms of stature. We may be facing a situation where cooperative breeding would be a decisive factor in the increased survival of newborns, but this increased survival would be negatively affecting biological well-being in the medium and long term due to a resource dilution. Even so, there are factors that are difficult to control that could be affecting the results (Schneider 2020). However, the results are consistent with the pre-existing literature cited above.

Obviously, due to the reduction in average family size (see Fig. 2) as a consequence of the fertility transition, large families (especially those with six or more children) became less common and almost disappeared from the last third of the twentieth century. This has undoubtedly had an effect on our results. The reduction in marital fertility also served as a mechanism to favor the height of all family members and enabled families to make greater investments in the few children conceived (Marco-Gracia and López-Antón 2021). The results of our models for those born between 1940 and 1979 indicate that only families that did not control their fertility and had a high number of living children displayed patterns similar to those of the previous period (societies with a large number of children). In addition, we must keep in mind that the height of these families is affected by many factors such as home hygiene and parental care. A previous study for the same study area showed that there is a strong correlation between shorter stature and percentage of deceased siblings (Marco-Gracia and González-Esteban 2021). Therefore, we should be aware that many forces are pulling in different directions at the same time until the configuration of the individual's stature upon reaching adulthood. In any case, it would be desirable to conduct further research on the relationship between height and number of siblings in low socioeconomic contexts to gain a better understanding of the influencing factors and the intensity of the impact.

We have observed clear differences between the two sub-periods studied, which would possibly be even more profound if we were to advance a little further in time. In the second sub-period, (birth cohorts 1940–79) the effect of the presence of older siblings is higher by about 20 percent to 50 percent depending on the age group at death and the sex of the sibling. However, this is possibly due to the fact that advances in health and hygiene knowledge meant that adequate care reduced childhood mortality. Thus, a greater presence of siblings may have increased the likelihood that one of the child's caregivers had adequate knowledge or applied it correctly according to parental instructions. The Spanish Civil War of 1936–39 saw an increase of more than 10 percent in childhood mortality, while the Second World War between 1939 and 1945 was not particularly felt (compared to the Spanish Civil War), although the 1940s were a time of poverty and disease (del Arco Blanco 2006).

At the same time, due to the availability of data and the period studied, the article has faced several limitations. These include our lack of knowledge of the actual temporal investment made by siblings and parents (even with gender distinction) in the rest of the offspring. Furthermore, we do not have precise information on family budgets and female paid labor. Moreover, in relation to the study of heights, we only have data for male conscripts. As a consequence, we cannot know how it affected the biological welfare of girls. In short, further and more in-depth research is needed for different periods and areas to answer with certainty the different questions related to the theories studied. In any case, this study represents a leap forward in our knowledge of the populations of inland Spain during the first two-thirds of the twentieth century. Observing the coherence between our case and the previous study for Aranjuez (Reher and González-Quiñones 2003) helps us to understand the effect of the strong family ties that have characterized southern Europe (Reher 2004) and to be able to compare them with the abundant studies for other world regions that we have previously cited.

Conclusions

In this article, we have studied the role of the number of siblings in relation to the survival of newborn children and their effects on biological well-being at 21 years of age. Our results seem to confirm the existence of a correlation between the number of alive siblings and increased chances of survival at 28 days, the first year, and the first five years of life. This effect was particularly strong in the second third of the twentieth century (among the birth cohorts 1940–79), when knowledge about hygiene and disease was more widespread, so that additional care and measures could have a more decisive impact.

Conversely, the increased survival of siblings in large families could have a negative effect. Our results show that, in the case of male conscripts at age 21, in the initial decades of the study, the biological well-being of male conscripts, as indicated by height, was significantly lower among those with a larger number of siblings. However, in the subsequent decades, the negative correlation between sibling size and height becomes statistically insignificant when the number of living siblings is fewer than five.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/ssh.2025.26.

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