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Occupational mobility and biological well-being: A perspective over three generations in rural Spain, 1835–1959

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ABSTRACT

This article analyses the effects of occupational mobility on biological well-being from a long-term perspective. While it is well known that occupation and heights were closely related in the nineteenth and early twentieth centuries, our analysis shows that variations in the occupational status of parents and social mobility relative to grandparents also help to explain the evolution of biological well-being in subsequent generations. Drawing on data on height and socio-economic status for almost 4000 individuals born between 1835 and 1959, this paper analyzes the effects of occupational changes on statures over three generations in a period when opportunities for access to land improved in rural Spain. Our results indicate that (1): there was a strong positive relationship between fathers' occupational status and children's biological well-being; (2) improvements in the parental socioeconomic status had a rapid impact on the height of the male children if this improvement occurred during the period when the sons were growing up, and (3) the social mobility of parents in relation to grandparents also had a noticeable effect on the height of their children.

1. Introduction

Economic modernization in rich countries over the last two centuries has been accompanied by a tendency for socio-economic status to be transmitted from parents to children (Solon 1992; Björklund & Jäntti, 2000, 2009; Black & Paul, 2011), and even from grandparents to grandchildren (Warren & Hauser, 1997; Björklund and Jäntti 2012; Modin et al., 2013; Hällsten, 2014). This is an important issue, since the intergenerational transmission of socio-economic status helps to explain the evolution of both income and biological well-being inequality (Piketty, 2019; Corak, 2013). Having a good socioeconomic position (linked to above-average income) favors a good diet for the family (both in terms of quantity and diversity of food). Therefore, the upward occupational mobility of the father during the children's growth process can have a positive impact on their nutrition and biological well-being. In addition, the upward mobility of the grandparents could also have an impact on the grandchildren.

The aim of this paper is to explore the effect of social mobility on biological wellbeing by analyzing microdata from 15 localities in rural Spain between 1835 and 1959. Our initial hypothesis is that the father's social mobility has a strong impact on the biological well-being of the child (positive or negative, depending on the direction of mobility). Meanwhile, the social mobility of the grandfather may affect the grandchildren if the improvement or deterioration did not directly transfer to the father (given that family economic improvement or deterioration could have occurred gradually) or if parental behavior varied according to family socioeconomic status (for example, it is possible that the feeding and care behavior of children of individuals who owned properties that could be sold in case of need was not the same as that of individuals without land, even if the incomes were similar).

This article is structured as follows. First, we conduct a brief literature review on the mechanisms of intergenerational transmission of socio-economic status and its effect on the outcomes of individuals in subsequent generations. In the following section we describe our database and the methodology we will use. Section 4 historically contextualizes the study area and analyses the main features of the economic transformation process experienced in this region. The empirical

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analysis is then divided into three sections referring to (1) the paternal occupation as a determinant of children's height, (2) changes in the paternal occupation throughout his life as a determinant of children's height, and (3) changes in father's occupational status relative to grandfather as a determinant of grandchildren's height. Finally, there is a discussion of the results which precedes a brief section of preliminary conclusions.

2. Intergenerational transmission of socioeconomic status and individual outcomes of subsequent generations

Understanding the historical persistence of both income and height inequality requires an understanding of multigenerational processes of transmission, especially in variables influenced by family legacy, such as occupational status or educational attainment (Mare, 2011; Helgertz & Dribe, 2019). The model proposed by Becker and Tomes (1986) is considered as the reference study par excellence on intergenerational transmission of socio-economic status and proposes that the socio-economic status of children would be the consequence of parental' investment in their offspring's human capital. Empirical studies for Western countries have found a connection between the outcomes of grandparents and grandchildren, taking into account the intermediate generation (Long & Ferrie, 2018; Chan & Boliver, 2013; Hertel & Groh-Samberg, 2014; Zeng & Xie, 2014; Braun & Stuhler, 2016; Lindahl et al., 2015; Dribe & Helgertz, 2016; Helgertz & Dribe, 2019). There are several hypotheses on how this intergenerational influence occurs (Solon, 2014). Zeng and Xie (2014) identify three pathways by which grandparents might influence the socio-economic status (and other outcomes) of their grandchildren, which are: (1) biological transmission, given that genes have an important impact on grandchildren's development (Beenstock, 2012; Björklund et al., 2006; Björklund et al., 2007); (2) the transmission of property, knowledge, human capital and social networks (Zimmerman, 1992; Mare, 2011; Pfeffer & Hällsten, 2012; Piketty, 2019), and (3) the socio-emotional pathway, through the grandchildren's upbringing and the transmission of cultural values (Solon, 2014). However, not all studies for Western countries confirm the existence of a connection between the outcomes of grandfathers and grandsons (Hodge, 1966; Warren & Hauser, 1997: Wolbers & Ultee, 2003; Jaeger, 2012; Bol & Kalmijn, 2016) and it must be acknowledged that empirical studies on this topic are subject to certain problems in terms of measurement and model specification (Solon, 2014; Clark, 2014; Clark & Cummins, 2015).

Our research focuses on whether changes in status had an impact on the biological well-being of the new generations and how this effect operated. It is well known that there has been a relationship between social class and stature over time and place (Goldstein, 1971; Schumacher and Knussmann, 1977; Bogin & Robert, 1978; Bielicki et al., 1981; Mascie-Taylor, 1984; Johnston, 1986; Alter et al., 2004; Kues, 2010; López-Alonso, 2012; Schoch et al., 2012;). The higher the parental socioeconomic status, the greater the height of their children when they reach adulthood. The relationship between socioeconomic status and height has been clearly contrasted in the Spanish context (Ayuda & Puche-Gil, 2014; Camara and Garcia-Roman 2015; Martínez-Carrión & María-Dolores, 2017; Candela-Martínez et al., 2022). This relationship would be the consequence of variables such as parental care, hygienic conditions at home, exposure to diseases and other factors experienced during childhood and adolescence (Peck & Lundberg, 1995; Crimmins & Finch, 2006; Webb et al., 2008; Dowd et al., 2009; Hatton & Martin, 2010; Marco-Gracia & González-Esteban, 2021). Poor and short individuals have experienced contexts of higher morbidity and mortality, and possibly less hygienic home environments (Drever et al., 1996; Marco-Gracia & Puche, 2021; Marco-Gracia & González-Esteban, 2021). It is to be expected, therefore, that changes in the occupational status of parents - throughout their lifetime or with respect to the grandparents' status – may have an impact on the biological well-being of children.

The process of economic modernization that has characterized the last two centuries has favored higher standards of living for most of the families, while contributing to the increasing trend in heights (Hermanussen & Scheffler, 2016). In the Spanish case, this process of economic modernization unfolded since the nineteenth century but accelerated notably from the second half of the twentieth century onwards (Prados de la Escosura & Rosés, 2021; Carreras & Tafunell, 2021). Individuals who experienced upward social mobility relative to their parents' generation were taller than those who experienced downward mobility and those who remained in the same socioeconomic category as their predecessors (Thomson, 1959; Schumacher and Knussmann 1979; Mascie-Taylor, 1984; Nystrijm Peck, 1992; Cernerud, 1995; Bielicki & Szklarska, 2000; Hart et al., 2008; Krzyżanowska & Mascie-Taylor, 2011, 2012). Regarding the impact of changes in parent's occupational category on children's height, the positive effect of upward social mobility was greater if it occurred in approximately the first seven years of children's lives (Lasker & Nicholas Mascie-Taylor, 1989), the first two years being particularly decisive (Schmidt et al., 1995; Victora et al., 2010). Moreover, it may well be argued that the positive effects of upward social mobility may only be captured in a multigenerational perspective, since several studies have shown that grandparents still have an impact on the socioeconomic status of their grandchildren and also influence their chances of social mobility (Warren & Hauser, 1997; Björklund and Jäntti 2012; Modin et al., 2013; Hällsten, 2014). However, much of the international literature does not find a relationship between social mobility between grandparents and parents and a persistent positive impact on the grandchildren's generation (Solon, 92, 2014). Changes in the socioeconomic status of parents may not be automatically reflected in the biological wellbeing of their children, since there could be mindsets associated with the grandparent's status that may persist and condition the investment patterns in children's well-being, even if parents had increased their status.

Our paper will try to shed light on these issues in several directions. First, we will check whether there was a relationship between the parents' occupation and the biological well-being of their children. Secondly, we will study whether changes in the father's occupational category throughout his life (i.e. personal upgrading/downgrading) influenced the height attained by his children. Finally, we will use a three-generation panel to analyse whether intergenerational mobility between father (2nd generation) and grandfather (1st generation) had an impact on the biological well-being of third-generation individuals. Hence, this paper is innovative for several reasons. First, it is the first of its kind that relates occupational mobility to the evolution of height over three generations. Second, although studies on intergenerational social mobility and height tend to have larger samples, our dataset allows for a longer-term perspective (1835–1959). Third, the existing studies on social mobility and height have never analyzed individuals from southern Europe as protagonists. Therefore, this paper opens up a possibility to make cross-country comparisons. Finally, the use of longitudinal data has allowed us to incorporate certain variables (such as migration and birth order) that are not always available in other studies.

3. Data and methods

This study focuses on a rural area in Aragon, in north-eastern Spain. This area is a combination of plains and foothills near the Huerva river which comprises 14 villages: Alfamén, Aylés, Botorrita, Codos, Cosuenda, Jaulín, Longares, Mezalocha, Mozota, Muel, Torrecilla de Valmadrid, Tosos, Valmadrid and Villanueva de Huerva (see Fig. 1). As these are small villages with no more than 2000 inhabitants, all neighbors reside in the same area sharing municipal services (such as sewage, school or doctor). Even so, there could be differences between rich and poor families (even in health) if the wealthier ones could count on servants to do the less hygienic chores, not having such a close coexistence with animals, or more space per person in their homes.

In this study we have used data from three different sources: (1) height data from military conscription records, (2) socio-economic data

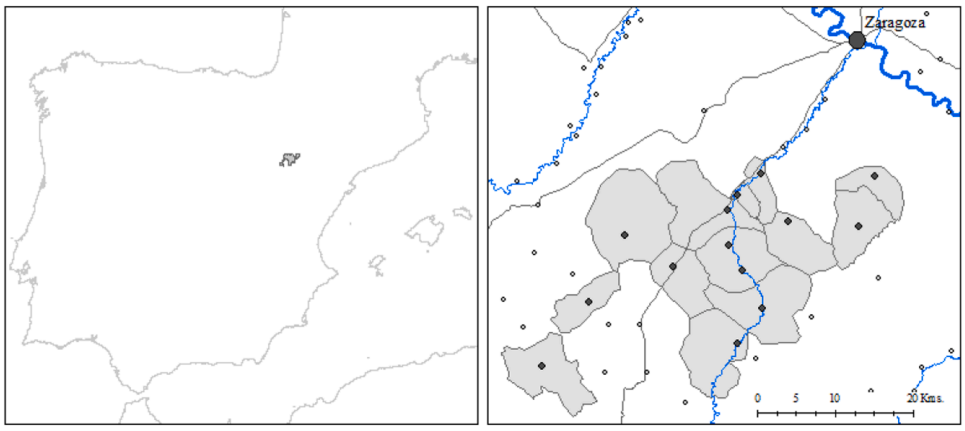

Fig. 1. Area of study: Middle Huerva (Aragón, Spain).
Source: Own rendering.

on occupation from censuses, population lists and parish registers and (3) individual demographic data from parish registers.

Regarding (1) *heights*, our data are drawn from military conscriptions recorded between 1855 and 1980. Approximately 95% of the data were obtained from the records kept in the municipal archives of each locality. To complete the sample, we requested a copy of the available conscriptions in the Historical Military Archive of Guadalajara. The age at conscription varied over time: during the period 1856–1885 age at military conscription was 20 years old; between 1885 (second call-up) an1899 it was 19 years; between 1901 and 1905 it was 20; subsequently it was 21 years of age. We have standardized the average height to the age of 21 years using the same strategy as Ayuda and Puche-Gil (2014) and have obtained similar results to those found in other Spanish regions (Ramón Muñoz, 2011; Ayuda & Puche-Gil, 2014). We have tested the null hypothesis of normality of average height for the whole period and cannot reject the null hypothesis for a significant level of 5%. Importantly, unlike selection biases found in other countries, Spanish sources of military recruitment include all individuals. The existence of a universal recruitment system since the 1830 s ensured that almost all recruits were measured, except for fugitives, and those who had died (therefore, there was no selection bias in the conscription process). Although several legal mechanisms existed between 1837 and 1936 to avoid compulsory military service, all of them occurred after measurement (Puell de la Villa, 1996). Individuals rejected for military service because of their short height or health problems were also registered. In fact, we have also included in our analysis the *appeals for exemption* variable, which provides information on the state of health of the conscripts at the time of measurement (appeals for exemption were applications submitted by the conscript themselves with the intention of legally avoiding military service). We have height data from 3390 individuals (i.e. third-generation individuals) born between 1880 s and 1950 s, although observations from the early decades are scarcer due to document preservation problems. We have been able to pool the height of 1293 groups of individuals from the first (grandfathers), second (fathers) and third (grandsons) generations, for which we have had to make several adaptations. We were able to match the height of 824 fathers and sons, which allowed us to calculate the difference in height between them. However, we have also generated an extended sample including individuals for whose father we have no height information. In those cases, we have used the average height of the father's male siblings. This is based on the idea that individuals belonging to the same household and sharing the same genetic load tend to have similar heights. This is an imperfect approximation, given that there is also a component of improvement in hygienic conditions over time and there may be other family, genetic and environmental variations. However, it can serve as a proxy when we do not have the father data (in fact, to avoid the associated bias problems, we have replicated in the regressions both with the father data and with the approximation proposed in different models so that the reader can be aware of the results with both possibilities). This method allowed us to add 469 observations to the original sample. Finally, we obtained a three-generation sample by merging the original two-generation sample (834 observations of fathers and sons) with the height data of the paternal grandfathers. This resulted in a small sample (256 observations), which, however, serves as a reference to ensure that the results of the extended three-generation sample are consistent. This is so low due to archival preservation problems. While in some villages there is perfect preservation (Longares and Mozota) in others the records for the older generations have preservation problems with the oldest records missing (not specific men but complete records). To solve this, we have used the copies sent to the army by the town halls but there are also random conservation problems for those born before 1890 s

To build the extended three-generation sample (1293 observations), we have used the average height of the grandfather's male siblings when the grandfather's height was not available (644 observations), the maternal grandfather's height only if he came from the same socioeconomic group (159 observations), and the mean height of the maternal grandfather's siblings of the same socioeconomic category (234 observations) when no other possibility was available. In all cases, we found the results to be consistent with each other, with no significant differences in mean height according to the criterion used.

The other fundamental variable for carrying out this study is (2) the *occupational category* of the individual. The occupational data were extracted from population lists (1857 and 1860), electoral censuses (we have taken a sample every five years from 1890 to 1955), and the parish registers for the intermediate period between 1860 and 1890, linking them to population records for every individual. All adult male individuals had to appear in all the above-mentioned sources except for the parish registers, which exhibit a more random behavior depending on the priest. Considering that the average age at marriage for men was generally between 25 and 30 years of age and that at that age most individuals had already started a family and were in full adulthood, we have considered 30 years old as the reference age for the occupational status of all individuals. Since the information for most of the observations has been obtained from censuses that are available every five years, we have considered the occupational category between 28 and 32 years of age. In addition, to gain a better perspective of what happened during the lifetime of individuals, we have also obtained information on the occupational category at about age 60. This will help us to differentiate between the parents who experienced occupational mobility during their lifetime and those who did not (or did so later). For adult individuals between 1890 and 1955, we have occupational data every 5

years or so (except for the period of the Spanish Civil War, 1936–1939, and thereabouts). For individuals from this period we have been able to verify that 46% of the men changed their socioeconomic status between 30 and 40, 89% had changed their status before reaching 50, and only 11% did so between 51 and 60. In other words, most of the changes in socioeconomic status occurred in the middle of the family's reproductive stage, while the children were still growing up.

As we shall see, since this is an eminently rural and agrarian area of study, we have divided the occupational groups into four socioeconomic categories[3]: (a) *low-skilled employees*, including day laborers and all types of landless and semi-landless workers without any specific knowledge (using the census of 1924, the average daily wage for a man in this category was 5.9 *pesetas*, standard deviation: 0.186); (b) *farmers*, who are landowners who could live off their crops. According to the census of 1924, the average daily wage in 1924 was 8 *pesetas* (standard deviation: 0.194). Low-skilled employees and farmers represent almost the 80% of the sample (see Marco-Gracia 2018a); (c) *craftsmen* (average daily salary in 1924: 9.6 *pesetas*, standard deviation: 0.704), and (d) *the upper class*, including individuals with occupations linked to specific knowledge, such as teachers and doctors, high ranking military men and train station masters. According to the census of 1924, heir average daily wage was 12.3 *pesetas* (standard deviation: 1.511) -in this category, most of the individual reported annual salary, therefore, we considered 300 days worked per year. Although the sample of artisans and upper class individuals is small, we believe it is useful to keep it, as it is evidence that owner-farmers can also be upwardly mobile (or inversely mobile).

Finally, (3) we have merged the height and the occupational data with additional information related to the family of the individuals, such as the *parity* (birth order) and *migration*. The familial and demographic data are drawn from the complete church registers of the villages. These records provide high-quality information on all baptisms, marriages and deaths that occurred between the sixteenth century and the twentieth century, including all individuals who were born and baptized in the reference parishes or who migrated to them and were registered. Our database was built following the family reconstitution method devised by Fleury and Henry (1956), which allowed us to reconstitute the life history of these individuals and their families, and this was the procedure used for intergenerational linkage.[4] We were also able to include a birth order variable (*parity*), which allows us to approximate the age of the mother when the child was born (since there is a correlation between the mother's age and parity). The *decade of birth* is a good indicator of both the demographic and socioeconomic modernization processes (including the slow changes in hygiene, water provision -in most cases, running water did not arrive until the 1970 s- and sewerage facilities). The *place of residence* is a control variable to determine whether there were significant differences in environmental or socioeconomic conditions across the villages. Table 1 shows a summary of the sample.

Table 1
Characteristics of the sample in relation to the average height, birth cohorts 1835–1959, 3390 observations.

	Variables	Cases	%	Average height	Std Deviation
Occupation	Low-skilled employee	2175	64.2	165.1	6.7
	Farmer	869	25.6	166.2	6.5
	Artisan	214	6.3	166.1	6.4
	Upper class	132	3.9	169.6	5.8
Father's occupation	Low-skilled employee	2224	65.6	165.1	6.7
	Farmer	803	23.7	166.2	6.4
	Artisan	225	6.6	166.4	6.1
	Upper class	138	4.1	169.8	5.8
Birth Decade	1830	19	0.6	156.0	5.7
	1840	99	2.9	162.8	5.9
	1850	19	0.6	157.7	5.1
	1860	72	2.1	161.1	5.6
	1870	89	2.6	161.7	6.1
	1880	71	2.1	164.5	6.3
	1890	129	3.8	163.1	5.4
	1900	316	9.3	163.5	6.1
	1910	383	11.3	164.4	7.0
	1920	577	17.0	164.5	6.3
	1930	544	16.1	166.4	5.8
	1940	461	13.6	167.5	6.2
	1950	453	13.4	169.0	6.1
	1960	148	4.4	170.3	6.6
	1970	10	0.3	170.7	8.3
Locality of residence	Alfamén	541	16.0	167.4	6.1
	Aylés	20	0.6	163.3	11.9
	Botorrita	139	4.1	167.2	7.1
	Codos	151	4.5	167.9	6.3
	Cosuenda	706	20.8	164.2	6.5
	Jaulín	170	5.0	166.1	7.0
	Longares	154	4.5	165.4	6.3
	Mezalocha	235	6.9	165.9	6.5
	Mozota	139	4.1	165.9	6.1
	Muel	374	11.0	166.5	6.1
	Torrecilla de Valmadrid	35	1.0	164.8	6.1
	Tosos	8	0.2	164.8	4.3
	Valmadrid	377	11.1	165.6	6.2
	Villanueva de Huerva	341	10.1	162.8	7.2
Physical appeals for exemption	0	3134	92.5	165.7	6.5
	1	256	7.6	164.3	7.8
Parity	1	719	21.2	165.4	6.4
	2	524	15.5	164.9	6.4
	3	420	12.4	165.9	6.4
	4	395	11.7	164.6	7.0
	5	1332	39.3	166.3	6.8

4. Occupational mobility in a changing agrarian world

Our study area covers around 500 kms^2, hosting a population of roughly 8000 inhabitants in 1860, 8200 in 1900 and 10,700 in 1940. The population lived in nuclear households and was essentially engaged in agriculture (mostly cereals and vineyards) and sheep grazing (Germán, 2012). As Table 1 illustrated, our sample is dominated by occupations linked to agricultural tasks: low-skilled workers (including day laborers and semi-landless workers) and farmers. Living standards were close to subsistence levels and average heights were lower than in other Spanish regions (Martínez-Carrión et al., 2016). Fertility rates were around six or seven children per family up to 1900 and mortality rates were also very high. However, the region underwent an important process of demographic and economic modernization during the period under study. Mortality rates began to decline in the last third of the nineteenth century due to the progressive advance of the

[3] We have not used international classifications (such as HISCLASS or SOCPO) because of the high concentration of individuals in two categories (farmers and low skilled workers). We believe that our classification is clear and efficient for the data available in the study area.

[4] The data were initially linked automatically using record linkage in Stata (version 16) but 100% of the unions were checked manually. In addition, we must consider that in Spain two surnames are used (paternal and maternal) and that we are working with small rural villages, so the linkage process is simple, and the subjects are easy to identify. Migrants who moved to the study area are left out of the analysis, as well as out-migrants, unless they are in the third generation and the migration occurred after the military record (at age 21). Finally, it should be noted that individuals who migrated within the villages of the study area are included regardless of generation.

epidemiological transition,[5] and average fertility also decreased from 1900 onwards. The region (Aragón) experienced a process of economic modernization from the second half of the nineteenth century, coinciding with the first wave of globalization. The economic transformation was particularly important in the regional capital, with the rural areas lagging behind (Germán, 2012). In 1857, Aragon was a relatively unindustrialized region even compared to other Spanish regions. However, Spain experienced a far-reaching modernization process and a significant improvement in health and living conditions over the following decades. The economic and demographic transformations that took place during this period help to explain the mobility observed in the sample.

Despite the arrival of agrarian capitalism, which conditioned the economic system and gradually necessitated larger agricultural properties to sustain a complete family, the rural study area remained predominantly populated by individuals engaged in agricultural tasks until the second half of the twentieth century. As a consequence of economic modernization, particularly from the 1960 s onwards, there was significant mobility of people between the countryside and the city. These migrations heavily impacted some of the study municipalities (Marco-Gracia 2018b). However, this modernization also led to the expansion of irrigated areas beyond the banks of the Huerva River. With the extension of irrigation, fruit and vineyard production increased during the second half of the twentieth century. The introduction of agricultural machinery reduced the need for agricultural laborers, who transitioned into industrial laborers, working in industrial areas within the localities themselves (mainly Muel and Alfamén) or nearby industrial zones. Craft production decreased during the twentieth century; however, in the 1980 s, efforts were made to revive the ceramics industry in Muel, gradually increasing its potential. Employment opportunities in the study area seldom require highly qualified professionals, leading natives with higher education levels to have incentives to migrate to urban areas. This region faces challenges in facilitating women's access to the labor market. Many women confront the dilemma of migrating to urban areas, commuting daily to access their jobs, or remaining as homemakers without a paid job contributing to the family budget. In most cases, the key phases of socioeconomic modernization occurred after the childhood and early youth of the individuals studied in this article, so the transformation in the second half of the twentieth century likely has minimal impact on our data.

The end of the nineteenth century and the beginning of the twentieth century were periods of increased access to land in Spain. The proportion of landless agricultural workers in relation to the number of tenant farmers and landowners -which we will refer to as the *salaried employment coefficient*- decreased by roughly 25% between 1860 and 1930 (Robledo & González-Esteban, 2017). Although the evolution of this coefficient was very uneven between regions (it increased considerably in many regions of southwest Spain which already had a major problem of access to land ownership in 1860), the municipalities in our sample are located in a region that fits the general pattern. Aragon was already characterized by a relatively strong presence of small landowners in 1860 and despite this, *salaried employment* tended to decrease in the municipalities of the sample (see Fig. 1. A in the Supplementary Material), maybe as a consequence of greater access to land for day laborers with the sales of the nobles, but rural-urban migrations may also have had an impact. Although the occupational categories in our sample do not explicitly refer to land ownership (as many individuals categorized as low-skilled employees had small plots of land), this process in which more and more day laborers gained access to land ownership is reflected in our occupational data. However, the existence of a general pattern does not mean that there was homogeneity in all municipalities, as family trajectories varied and changed over time. This can best be seen in Table 2.

As may be observed, there was a strong tendency towards intergenerational immobility in the study area since the occupational categories of parents and children tend to coincide (especially between individuals from the first and the second generation). This result is similar to those of other studies in different rural contexts around the world as in the case of Sweden (Dribe & Helgertz, 2016). The process of economic and social transformation at the end of the nineteenth century and the first decades of the twentieth century is reflected in the fact that occupational mobility between individuals of the second and third generations is considerably greater than between those of the second and first generations. Importantly, while many individuals experienced upward mobility from the second to the third generation (29.8%), there was also a significant percentage of the children (22.6%) who experienced downward mobility. This can be understood as the result of a process of agrarian transformation in which there were forces pulling in different directions. On the one hand, increased opportunities for access to land resulted from the fact that noble families became open to selling their properties. With the definitive end of the lordships in 1837, the nobles and religious orders that concentrated seigniorial power lost many of their 'rights'. Initially, they were able to maintain control over the land and mainly continued to rent it for grazing as they had done in the past. However, improvements in land productivity associated with the increased use of fertilizers and ploughing technologies drove landowners to dedicate land to crops instead of renting it for grazing (Pinilla, 1995). This entailed extra expenses such as the hiring of guards to ensure that no-one could enter the lands without permission, which contributed to the decision of many noble families to sell their land and so they could concentrate on forging their urban patrimony. During the second half of the nineteenth century and the first decades of the twentieth century, a large part of the lands that had belonged to the manors was sold. For example, in the largest locality in the study area, Alfamén, of the 21 existing meadows, 20 still belonged to the Marquis of Camarasa in 1850 but none in 1950 (Marco-Gracia, 2011). The villagers organized themselves to put pressure on the administrators of the large landowners and obtain a significant part of these lands sold in lots to the villagers themselves. All this created a climate in which many landless and semi-landless workers were able to gain access to land ownership.[6] On the other hand, however, our occupational data show that there were also a significant number of individuals who remained as low-skilled workers (landless or semi landless), often as a result of a process of downward mobility vis-à-vis the father. This is explained by the fact that part of the land belonging to the nobles was not sold to the villagers but to large landowners (Marco-Gracia, 2011), and also because the period under analysis corresponds to a process of demographic transition with high fertility rates and high population growth. The relatively weak process of industrialization and limited structural change often meant that when the father died, his land was divided among many siblings who continued to live in the countryside. Moreover, being an inland area, far from the main ports, there was hardly any overseas migration, and rural-urban mobility took place mainly in the second half of the twentieth century. The richness of our database lies in the fact that it offers a great diversity of family trajectories that form part of a broad

[5] In a generalist and open definition, this concept includes the reduction of disease load, improvements in sanitation and, to a lesser extent in the study area, in access to water, immunization, nutrition, improvement of sanitary knowledge, etc.

[6] If the farmer was already exploiting the nobleman's land under a permanent lease, we consider that at all times that family maintains the consideration of farmer. However, if the individual who was previously a laborer (hired by the nobleman or by the settlers) gains ownership of the land, we consider this as upward mobility. We must bear in mind that in the negotiations between nobles and villagers, cheap conditions were sometimes given so that the laborers could gain access to land ownership (in exchange for other concessions such as the nobleman's freedom to sell other plots to whomever he wished without having problems with the villagers).

Table 2
Tables of intergenerational occupational mobility (second-third generation, and first-second generation) in number of observations and percentage, birth cohorts 1830–1950 s.

		Individuals (3rd Gen)				
		Low Skilled Workers	Farmers	Artisans	Upper Class	Total
Fathers (2nd Gen)	Low Skilled Workers	263	328	2	1	594
		(44.28)	(55.22)	(0.34)	(0.17)	(100.00)
	Farmers	257	325	33	16	631
		(40.73)	(51.51)	(5.23)	(2.54)	(100.00)
	Artisans	8	14	18	6	46
		(17.39)	(30.43)	(39.13)	(13.04)	(100.00)
	Upper Class	4	9	1	8	22
		(18.18)	(40.91)	(4.55)	(36.36)	(100.00)
	Total	532	676	54	31	1293
		(41.14)	(52.28)	(4.18)	(2.40)	(100.00)
		Fathers (2nd Gen)				
		Low Skilled Workers	Farmers	Artisans	Upper Class	Total
Grandfathers (1st Gen)	Low Skilled Workers	509	158	8	2	594
		(75.18)	(23.34)	(1.18)	(0.30)	(100.00)
	Farmers	77	466	12	6	561
		(13.73)	(83.07)	(2.14)	(1.07)	(100.00)
	Artisans	3	4	26	1	34
		(8.82)	(11.76)	(76.47)	(2.94)	(100.00)
	Upper Class	5	3	0	13	21
		(23.81)	(14.29)	(0.00)	(61.90)	(100.00)
	Total	594	631	46	22	1293
		(45.94)	(48.80)	(3.56)	(1.70)	(100.00)

Source: author's elaboration from the dataset

process of economic and social transformation of the Spanish countryside.

Finally, it is noteworthy that traditionally, socioeconomic categories have been strongly linked to income, as evidenced by the 1924 census in the study area, which is the only one providing individual-level wages for men. These categories are also tied to prestige and social position (Harding, 1984). Possibly, it was not until economic modernization, the end of the Franco dictatorship (1970 s), and the beginning of the democratic regime based on individual freedoms that the gap between social classes began to narrow. Rural villages became particularly homogeneous, and social categories lost importance (Collantes & Pinilla, 2011). Until the last decades of the twentieth century (i.e., after the period covered by our study), socioeconomic status was strongly linked to income, life opportunities, and individual behavior (Harding, 1984).

5. Empirical analysis

In this section we will analyze how occupational mobility affected the levels of biological well-being. We have estimated 12 multivariate regression models (Tables 3–5) using ordinary least squares (OLS) linear regressions with heteroskedasticity-robust estimation. All models can be denoted as follows:

$$y_i = \beta_1 * X_{1i} + \beta_2 * X_{2i} + \beta_3 * X_{3i} + \cdot\cdot + \varepsilon$$

where y is the dependent variable for an individual i, X_n denotes the independent variables and ε is the error term. The dependent variable in the models in Table 3 is the height of the individual, whereas the dependent variable in the models in Tables 4 and 5 is difference in height between the individual and his father or paternal grandfather (specified in each subsection).

5.1. The paternal occupation as a determinant of children's height

It is well known that an individual's occupation (and that of his father) is highly correlated with his height (Alter et al., 2004; López-Alonso, 2012; Schoch et al., 2012; Ayuda & Puche-Gil, 2014). In fact, this historical correlation between height and socioeconomic status has been extensively demonstrated in the Spanish context (e.g., Ayuda & Puche-Gil, 2014; Cámara et al., 2019; Marco-Gracia & Puche, 2021). To confirm that this relationship exists in our sample, we have estimated four models (see Table 3) with the individual's *height* in centimeters as the dependent variable. Considering that during the period under study there was a substantial improvement in living standards and, consequently, a significant increase in the average height (Marco-Gracia and González Esteban, 2021), all models control for the *decade of birth*. In the first model we have exclusively analyzed the relationship between the *father's socioeconomic category* and the height of the child. In models 2, 3 and 4 we have also included the individual's *locality of residence* as a control variable. In the third model, we have included a variable indicating whether the individual claimed to have *physical problems* in order to avoid military service. Finally, the fourth model also includes the variable *parity* (the individual's birth order), which serves as a control for certain characteristics of the family household -such as the age of the mother- that might have affected the individual's growth.

All models confirm that farmers' children were significantly taller than those of low-skilled employees (roughly 1 cm higher). Belonging to the lowest socio-economic groups in a society with low living standards was associated with poorer living standards during childhood and adolescence, possibly because of poorer nutrition, a less hygienic living environment and greater exposure to disease or inadequate development due to an excessively early entry into the labor market (Drever et al., 1996; Marco-Gracia & González-Esteban, 2021). This result reinforces the interest of our study, since it shows that in a fully agrarian society, there were differences in biological well-being according to land ownership, and it is interesting to study how mobility between these categories affected changes in biological well-being. The models also indicate a significant height premium (more than 2 cm) for the children of upper-class parents. Regarding the appeals for exemption variable, it should be noted that those who claimed to have physical problems in order to avoid military service were, on average, more than 1 cm shorter than the rest. The results regarding the birth order (*parity*) are not conclusive. Finally, the models show no relationship between the place of residence and heights, which was expected, given that all villages had a similar socio-economic structure.

Table 3
Determinants of individual height, rural Aragon, birth cohorts 1890–1950 s.

Variable	Categories	(1)	(2)	(3)	(4)
Father's occupation	Farmer	(ref.)	(ref.)	(ref.)	(ref.)
	Low Skilled Employee	-1.11 * **	-0.90 * **	-0.90 * **	-0.90 * **
		(0.25)	(0.26)	(0.26)	(0.26)
	Artisan	-0.3	-0.01	0	0.01
		(0.47)	(0.47)	(0.47)	(0.47)
	Upper Class	2.07 * **	2.55 * **	2.55 * **	2.54 * **
		(0.58)	(0.57)	(0.57)	(0.57)
Appeals for exemption	No appeal (fit to serve)			(ref.)	(ref.)
	Physical appeals			-1.00 *	-0.99 *
				(0.4)	(0.4)
Parity	1				(ref.)
	2				-0.62
					(0.35)
	3				0.4
					(0.37)
	4				-0.27
					(0.38)
	5 or more				-0.01
					(0.29)
Intercept		156.64 * **	155.81 * **	156.18 * **	156.35 * **
		(1.42)	(1.44)	-(1.44)	(1.45)
Control Decade of Birth		YES	YES	YES	YES
Control Village		NO	YES	YES	YES
	N	3390	3390	3390	3390
	R-sq	0.151	0.187	0.188	0.19

Source: Parish registers, censuses and conscription and call-up records; historical municipal and parish archives from municipalities composing the anthropometric sample and conscription records of the Military Archive of Guadalajara (Spain).
* Statistical significance at 10% level.
* * Statistical significance at 5% level.
* ** Statistical significance at 1% level.

Table 4
Relationship between occupational upgrading/downgrading of the parents during their life and height of their children in rural Aragon, birth cohorts 1860–1950 s.

		Difference in height betwen father and child			Difference Father's family - child
Variable	Categories	(1)	(2)	(3)	(4)
Father's occupational mobility	Same	(ref.)	(ref.)	(ref.)	(ref.)
	Upward	5.26 * **	4.11 * *	4.29 * *	5.79 * **
		(1.43)	(1.49)	(1.47)	(1.02)
	Downward	1.41	1.5	1.25	1.21
		(0.97)	(0.97)	(0.96)	(0.94)
Appeals for exemption	No appeal (fit to serve)	(ref.)	(ref.)	(ref.)	(ref.)
	Physical appeal		-1.5	-1.55	-1.56 *
			(0.96)	(0.96)	(0.76)
Father moved to another village	No			(ref.)	(ref.)
	Yes			3.81 * **	2.25 * *
				(0.95)	(0.75)
Parity	1			(ref.)	(ref.)
	2			0.15	-0.61
				(0.61)	(0.50)
	3			0.5	-0.21
				(0.69)	(0.55)
	4			0.84	0.36
				(0.86)	(0.66)
	5 or more			-0.19	-1.03
				(0.79)	(0.58)
Control Decade of Birth		YES	YES	YES	YES
Control Village		NO	YES	YES	YES
Intercept		2.52 * *	3.22 *	2.52	1.87
		(0.92)	(1.35)	(1.39)	(1.10)
N		824	824	824	1293
R-sq		0.028	0.054	0.074	0.06

Notes: OLS estimates; *se* denotes robust standard error.
Source: Parish registers, censuses and conscription and call-up records; historical municipal and parish archives from municipalities composing the anthropometric sample and conscription records of the Military Archive of Guadalajara (Spain).
* Statistical significance at 10% level.
* * Statistical significance at 5% level.
* ** Statistical significance at 1% level.

Table 5
Relationship between social mobility (occupational mobility from the first to the second generation) and heights of the third-generation individuals in rural Aragon, birth cohorts 1830–1950 s.

		Grandfather (extended) -Grandchild			Grandfather-Grandchild
Variable	Categories	(1)	(2)	(3)	(4)
Intergenerational Social Mobility	Same	(ref.)	(ref.)	(ref.)	(ref.)
	Upward	0.97 * *	1.09 * *	1.00 * *	5.37 * **
		(0.33)	(0.34)	(0.34)	(1.5)
	Downward	-0.87	-0.87	-0.90 *	-0.32
		(0.45)	(0.45)	(0.45)	(2.27)
Appeals for exemption	No appeal (fit to serve)		(ref.)	(ref.)	(ref.)
	Physical appeals		-0.8	-0.8	-0.97
			(0.47)	(0.47)	(2.09)
Grandfather moved to another village	No			(ref.)	(ref.)
	Yes			0.90 * *	2.63 *
				(0.31)	(1.23)
Parity	**1**			(ref.)	(ref.)
	2			-0.08	-1.53
				(0.31)	(1.22)
	3			-0.26	-1.01
				(0.34)	(1.45)
	4			-0.09	1.19
				(0.41)	(1.97)
	5 or more			0.15	3.02
				(0.36)	(1.67)
Control Decade of Birth		YES	YES	YES	YES
Control Village		NO	YES	YES	YES
Intercept		3.94 * **	3.88 * **	3.87 * **	4.79
		(0.5)	(0.66)	(0.69)	(3.74)
N		1293	1293	1293	256
R-sq		0.024	0.034	0.041	0.245

Notes: OLS estimates; *se* denotes robust standard error.
Source: Parish registers, censuses and conscription and call-up records; historical municipal and parish archives from municipalities composing the anthropometric sample and conscription records of the Military Archive of Guadalajara (Spain).
* Statistical significance at 10% level.
* * Statistical significance at 5% level.
* ** Statistical significance at 1% level.

5.2. Changes in parental occupational status (personal upgrading/ downgrading throughout his life) as a determinant of children's height

Given that we not only know the occupation of the parents in their thirties but also at older ages (around age 60 or his last observation if he died before reaching this age) we can explore whether parents experienced occupational mobility during their adulthood. This is particularly interesting, since it is the period in which most parents gave birth and raised their children. As mentioned before, we have (1) a basic database of 824 cases in which we know both the height and the socioeconomic status of fathers and sons and (2) an extended database of 1293 cases that also includes 469 individuals for whom we have no information on the father, but for whom we do have information on the father's male siblings.

To analyze the effect of the paternal occupational upgrading/ downgrading (i.e. personal occupational mobility throughout his life) on children's height, in Table 4 we have run four ordinary least squares (OLS) linear regressions in which the dependent variable is the difference in height between father and son (models 1–3), and the difference in height between the paternal family (including the father) and the son (in model 4). The variable *fathers's occupational mobility* refers to the paternal personal mobility and follows a basic distribution of three options: no mobility, upward mobility, and downward mobility. The variable *birth decade* is included in all models in order to control for the overall increase in height that accompanied the general improvement in living standards. Model 2 replicates model 1 but also includes the claims of having physical problems in order to avoid entering military service. Model 3 builds on the previous model and includes a new variable that accounts for parental migrations before the child is born.[7] Model 3 also includes parity. Finally, model 4 replicates model 3 using the extended sample, thus using as a dependent variable the difference in height between the son and the father's male siblings.

Models 1–4 allow us to delve deeper into the effects of paternal occupational mobility on children's height. The basic model 1 shows that parental upgrading had a positive and significant impact on the son's stature (a height premium of more than 5 cm compared to the children of parents who remained in the same occupational category). There is indeed a very strong positive correlation between the height of sons and the fact that their fathers improved their occupational status during adulthood (the childhood of their sons). On the other hand, the occupational downgrading of the father does not appear to be significantly associated with alterations in offspring height. These results hold for models 2, 3 and 4, which incorporate different control variables. We know that there were differences at salary level among the socioeconomic groups, but maybe sometimes a downgrading had not big implications in the salary (maintaining the downgrading people among the highest wages of the lower category). Regarding the other explanatory variables, the one referring to the father's migration stands out. Children born in a village other than the father's were, *caeteris paribus*, significantly taller (2–4 cm) than those whose father did not migrate. Possibly the explanation for these results lies in the motivations for moving from

[7] The variable *Father moved to another village* takes the value 1 if the child is born in a locality other than that of the father and zero if born in the same locality.

one village to another. While it is true that a significant proportion of men migrated for marital reasons (approximately 55%),[8] many others also did so in order to improve their standard of living. Importantly, this improvement in the living conditions of the parents could take place without the need for them to change occupational category (i.e. they could improve their living conditions while remaining semi landless agricultural workers, since increased opportunities to access small plots of land sometimes could only be taken by moving to a new village). This result is consistent with other studies that have analyzed the effects of geographic mobility, such as that of Krzyżanowska, and Mascie-Taylor (2012) for England. Moreover, the variable referring to paternal migrations helps to control for other factors, such as the fact that, in the marriage market, there is a preference for individuals of above-average stature (Manfredini et al., 2013). We believe that controlling for the geographical mobility of the father adds additional value to the results obtained in relation to changes in his occupational category. Finally, from the results in model 4, it should be noted that physical problems were probably linked to smaller heights. With regard to p*arity,* it probably only played a negative effect in high parities -which are associated with older mothers at childbirth and hence greater health risks for the newborn- although coefficients are not significant.

5.3. *Changes in father's occupational status relative to grandfather (intergenerational social mobility) as a determinant of grandchildren's height*

Finally, we will analyze in greater depth the impact of intergenerational social mobility on the height of individuals in subsequent generations. The analysis of three generations will allow us to see to what extent improvements in the occupational status of the father relative to the grandfather had an impact on the height attained by the grandchildren. All estimated models in Table 5 take the difference in height between the first and the third generation as the dependent variable and control for the decade of birth of the third-generation individual. Model 1 is the most basic and only introduces intergenerational social mobility as an explanatory variable (apart from the control for decade of birth). The second model incorporates the appeals of physical problems to avoid military service of the third generation and, as a control variable, the place of residence. Model 3 replicates model 2 but also includes a control variable for grandfathers' migration - -which takes the value 1 if the father is born in a different locality than the grandfather and 0 if born in the same locality- and also includes *parity*. Finally, while models 1,2 and 3 use the extended sample, model 4 takes as the dependent variable the difference in height between the paternal grandfather and the grandchild (thus reducing the sample to 256 individuals).

Models 1–4 confirm the existence of a strong positive and statistically significant link between upward intergenerational mobility and the height attained by subsequent generations. In all models the coefficients associated with the father's occupational improvement relative to the grandfather's are significant in explaining the increase in grandchildren's height (the effect being particularly strong in model 4, which uses the original sample). In the case of downward mobility, the coefficients are negative but generally not significant (as in the case of the variable *appeals for exemption*). Particularly striking is the fact that grandfather migrations had an effect that lasted for two generations, as the grandchildren of those who migrated were, *caeteris paribus*, taller than the grandchildren of those who remained in their place of birth (between 0.9 and 2.6 cm, see models 3 and 4). This outcome is consistent with that of the previous section, and reinforces the idea that migration in search of better living conditions contributed to increasing the biological well-being of the following generations. Moreover, given that in some cases migrations were also produced for marital reasons, we consider that controlling for this variable strengthens the results obtained with respect to the independent variable that interests us most, which is the intergenerational occupational mobility. Finally, as in the models presented in the previous sections, the rest of the variables (the control for village and *parity*) are not significant.

6. Discussion

Our study confirms that positive occupational and social mobility was related to an increase in height of subsequent generations, as has already been demonstrated for other areas of developed countries (Mascie-Taylor, 1984; Cernerud, 1995; Bielicki & Szklarska, 2000; Hart et al., 2008; Krzyżanowska & Mascie-Taylor, 2011 2012). The low pre-existing living standards throughout the period analyzed– despite the significant improvement resulting from the modernization process– have allowed us to capture a very visible effect of changes in socio-economic status on biological well-being. Our results are particularly strong in the case of the individuals whose fathers increased their occupational (and, therefore, socioeconomic) status throughout their adulthood, with their children having the opportunity to benefit from these improvements in their childhood or adolescence (see Section 5.2). Moreover, we believe that one of the main contributions of this study is the three-generation perspective, which has allowed us to study the impact of intergenerational social mobility on the height of third-generation individuals as well as capturing some of the long-lasting effects of migration. Even if an individual does not change socio-economic status, residential change may be related to improvements in his living standards. For example, agricultural laborers (most of whom were in the lower socio-economic status group) probably moved to villages where more days of work per year were demanded or better-paid work opportunities existed (among other reasons for migration). Our results suggest that migration had a positive and very significant impact on heights (that of parents towards children but also that of grandparents towards grandchildren). We believe that this reinforces the interest of this article in studying occupational and social mobility over three generations. Finally, the family variables included in the analysis (i.e. *parity*) showed hardly any significant effect, as found in previous studies (Deary et al., 2005).

Despite its interest, our study has some limitations. First, there may be a causality issue. Some studies emphasize that physical appearance (in relation with health) may have been a determining factor in upward occupational and social mobility (Young & French, 1996; Huang et al., 2002; Judge & Cable, 2004; Cinnirella & Winter, 2009). This means that the relationship between social mobility and height may not only be one-way: upward social mobility could also have been the consequence of taller and healthier physical appearance. However, in our study area, social ascent often implied the purchase of new land, which suggests that physical appearance was not so relevant (the only exception would be social mobility through marriage). We should bear in mind, however, that there may be some cases in which physical appearance facilitated upward occupational and social mobility and not the other way around.

Second, our results do not confirm (in contrast to most of the previously cited studies) the negative impact of downward occupational and social mobility on height. We consider this result to be provisional, as it may be the case that the negative effect of downward mobility was compensated by other mechanisms that we have not been able to control for, such as food support from other members of the extended family (even if they did not live in the same household). More research is needed to investigate the relationship between downward mobility and height in rural Spain.

Third, we should take the results with caution due to the small size of the sample in some models (under 300 families). More research is needed to confirm (or not) our results and explanations.

Finally, we believe that one of the most important limitations of this

[8] Percentage of men in the study area who marry a woman from another village and take up residence in her village. However, we do not know whether they move after marriage or were already residing in the new locality when they met their wife.

study is related to selection biases. Migration from the area of study constitutes a limitation in the interpretation of the three-generation analysis, since third-generation individuals who migrated were left out of the study. Although the household and demographic profiles of those who migrated as adults do not differ significantly from those who stayed (Marco-Gracia 2017, 2021), there are certain biases (such as the higher likelihood of being among migrants with higher education such as teachers or doctors) that could have had some effect on the results and their representativeness. In addition, there could be other unknown biases among migrants, such as the greater ease of migration of landless individuals because they were not conditioned by ownership. Another limitation is that we are analyzing 15 rural villages in Aragon, which are not necessarily representative of the Spanish rural environment. That said, the rural area of study and the historical process is similar to most of the country (especially inland Spain) and we have no evidence to indicate that our study area presents differential characteristics that would condition our results for a traditional Spanish rural area. We believe that the results presented in this article make a relevant contribution to the study of intergenerational occupational and social mobility and its effects on inequality in biological well-being. Despite its limitations, this is a "micro" analysis that would be nearly impossible to carry out with aggregate sources with more data and covering large areas. Thus, we must use a smaller sample, accepting its limitations, in order to be able to conduct a study with this depth of analysis. In any case, new case studies for different areas and periods would be of great interest to confirm or refute the results obtained in this paper.

7. Conclusions

This article analyzes the effect of intergenerational occupational and social mobility on the height of individuals from 14 Spanish villages. The process of economic and social transformation that accompanied these villages motivated different family trajectories of occupational mobility, most of which implied changes in the degree of land ownership.

The results obtained have largely confirmed our initial hypothesis, although not entirely. They show that upward mobility was clearly associated with an improvement in biological well-being, the effect being especially important if the father moved up the occupational ladder in adult life (i.e. during the period of raising his children). As the living conditions of families improved, so did the children's well-being.

To a large extent, we wanted to know whether parents who increased their socioeconomic status over their lifetime did so by sacrificing family welfare (reinvesting family income in property or other productive assets) or did the improvements have an impact on the welfare of the children from the outset. Our study shows that families who saw their incomes improve with access to land ownership (or increased land availability) did not keep their improvements exclusively in the form of savings but invested at least part of it in improving the living conditions of their children. Therefore, the improvement that the father experienced over his lifetime was not only an investment in the future but also had an immediate impact on his family. However, our results have not been equally clear regarding the downward social mobility of parents (possibly due to the sample).

Another major question considered is what happens if the change in socioeconomic status occurs between the grandparent and the parent, the three-generation perspective has allowed us to further explore how changes in the past could still have a positive effect after two generations. For example, the residential change of both fathers and grandfathers is associated with strong improvements in son's and grandson's height. This may indicate that residential change was associated with an improvement in living standards even if there was no change in the occupational category. These results regarding the impact of grandparents' social mobility on grandchildren are also partially consistent with our initial hypothesis. However, we have seen throughout the article that the impact of the father's change in socioeconomic status is greater than the impact of intergenerational mobility.

Declaration of Competing Interest

None.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.rssm.2023.100870.

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