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THE URBAN-RURAL HEIGHT GAP: EVIDENCE FROM LATE NINETEENTH-CENTURY CATALONIA

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Resumen

Este trabajo tiene como objetivo determinar si existía, y en qué medida, una brecha en los niveles de vida biológicos entre las zonas rurales y urbanas de la Cataluña de finales del siglo XIX. El estudio utiliza una nueva y extensa base de datos obtenida de registros militares para la cohorte de hombres nacidos en el año 1890 y alistados en el año 1911. A partir de la combinación de datos individuales con información a nivel municipal, llegamos a la conclusión de que en la cohorte de nacidos en 1890 la estatura de los reclutas que vivían en las áreas rurales era menor que la de los que residían en poblaciones de más de 20.000 personas. Asimismo, formulamos algunas hipótesis sobre las razones por las que los habitantes de la Cataluña urbana eran más altos que sus homólogos rurales.

Palabras clave: nivel de vida biológico, bienestar, penalización urbana, ventaja urbana.

JEL Codes: N33, N93, I14, I31.

Abstract

This paper aims to establish whether there was a gap in biological living standards between rural and urban areas in late nineteenth-century Catalonia, and if so, to determine its extent. The study makes use of a large new dataset based on military records for the cohort of males born in the year 1890 and enlisted in the year 1911. By combining individual heights with information at municipal level, we conclude that the 1890 cohort of conscripts living in rural areas were shorter than those that resided in towns and cities with populations of more than 20,000 people. We also hypothesize about the reasons why urban dwellers in late nineteenth-century Catalonia were taller than their rural counterparts.

Key words: biological living standards, well-being, urban penalty, urban premium.

JEL Codes: N33, N93, I14, I31.

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1. Introduction

The comparison of historical human heights between urban and rural populations has become a well-established area of research. Mean human height is a measure of biological living standards, and is a good indicator of the nutritional status and the health of populations. A comparison between populations of different sizes and functions may therefore contribute to a better understanding of health inequality (Blum 2016: 180), a central topic in social sciences and policy-making.

While the available evidence identifies certain empirical regularities, it also suggests that urban-rural divergence (or convergence) in health and well-being differs over time and across territories. This paper explores the case of Catalonia, a prosperous industrial area in north-eastern Iberia with a per capita income in the second half of the nineteenth century that was converging with that of Western Europe (Carreras 2019). With about 30 per cent of its workforce employed in industry in 1900, Catalonia had also become a leading manufacturing centre as well as one of the regions with the highest per capita income in Southern Europe (Nadal 1975, Díez-Minguela, Martínez-Galarraga, and Tirado 2018, Wolf and Rosés 2020).

Did Catalonia's industrialisation and modern economic growth lead to the emergence of height differences between rural and urban areas? We attempt to answer this question by using a unique dataset that includes height data for a large percentage of males born in 1890 who were living in Catalonia in 1911. This evidence allows us to avoid potential shortcomings associated with the use of small and potentially biased samples, and it may also shed new light on the complex and changing relationship between population size and height.

The comparison of biological living standards between urban and rural areas has attracted the attention of a large number of scholars. This is particularly true in north-western Europe; there, a large body of historical research shows that in the first stages of modern economic growth between the late-eighteenth and the mid-nineteenth centuries the combination of industrialisation and rapid population growth resulted in an urban height penalty (e.g. Komlos 1985 and 1998, Riggs 1994, Ó Grada 1996, Drukker & Tassenaar 1997, Baten & Murray 2000, A'Hearn 2003, Haines 2004, Heyberger 2007, Cinnirella 2008, De Beer 2010, Heyberger 2014, Kok, Beekink & Bijsterbosch 2018, Tassenaar 2019, Groote & Tassenaar 2020, and for summaries, Steckel & Floud 1997a, Komlos & Baten 2004, Floud, Fogel, Harris & Hong 2011, Blum 2016, and Meinzer & Baten 2016).[1]

Various reasons contribute to explaining why the heights of urban dwellers decreased relative to rural heights. Workload, nutrition and diseases influence height; and in urban areas these factors evolved in way that negatively affected the physical stature of the population. In Britain, for example, several cities grew up in

[1] Nevertheless, for the particular case of Alsace, Heyberger (2007:237) found similar heights in urban and rural areas until about the 1840s, "when the two diverged until the end of the century, as is expected for the height of urban inhabitants". This author argued that "it is unusual that the rural–urban divergence in height happened relatively late in Alsace (1840s) and even at its peak in the 1850s birth cohorts it was only about 1 cm-lower than in many other parts of the world". On the other hand, Kok, Beekink & Bijsterbosch (2018) stress the importance of the compositional effect in explaining urban-rural differences: e.g. poorer families are more likely to be found in cities.

parallel to the spread of factory-based industrialisation, and this process transformed both working and living conditions. Apart from the more regular, monotonous and disciplined working patterns of the mechanized factories, leisure time declined as working hours increased by around 25-30 per cent in the century after 1750 (Thompson 1967, Clark 1994, Voth 1998, 2001, 2003). Child labour was also used intensively during the Industrial Revolution (e.g. Humphries 2010). While working conditions probably became harder between the mid-eighteenth and the mid-nineteenth centuries, this was compensated, to some extent at least, by gains in other indicators of living standards such as real wages from around 1800 onwards (e.g. Feinstein, 1998, Allen 2009, Horrell 2014, Gallardo-Albarrán & de Jong 2021). On the other hand, food consumption (measured by trends in daily calories per person) declined or, at best, remained stagnant between 1750 and 1850 (e.g. Meredith & Oxley 2014a, Meredith & Oxley 2014b, Broadberry, Campbell, Klein, Overton, van Leeuwen 2015, Floud, Harris & Hong 2015, and Harris 2016). In addition, diets were in general less diverse and poorer in industrial than in rural areas (e.g. Meinzer & Baten 2016), and, in general, food supply was more dependent on the market, making urban dwellers more vulnerable to periodical food shortages due to transport limitations and crop fluctuations (Komlos 1998). Moreover, urban factory workers were probably less exposed to sunlight and the production of vitamin D than rural labourers, a circumstance that may also have influenced height trends across these two subgroups (Carson 2009). Finally, the new industrial cities of Britain and elsewhere tended to be overcrowded and had poor housing and sanitary conditions (Floud, Fogel, Harris & Hong 2011: 171). Clean water was often in short supply and the sewerage systems were substandard (Hassan 1985). All this created an unhealthy environment that promoted the transmission of infectious and contagious diseases.[2]

The emergence of an urban height penalty is, in fact, associated with a more general issue: the 'early industrial growth paradox or puzzle', namely, a fall in physical stature in a period when economy was growing. A similar pattern was found in the United States, termed the 'Antebellum puzzle' (Komlos 1998). Recently, the existence of an industrialisation puzzle has been questioned (Bodenhorn, Guinnane & Mroz 2017); however, the most recent papers support the presence of shrinking heights in a growing economy (Zimran 2019, Heyberger 2007, Komlos & A'Hearn 2019; Komlos 2019).

The urban height penalty did not last forever. The gap between rural and urban heights declined over time and finally the urban penalty (rural premium) reversed into an urban premium (rural penalty). The construction of the railways, and domestic and international market integration, increased the supply of food products in urban areas, making the earlier nutritional advantages of rural settings less apparent (e.g. Blum 2016). Public investment in clean water supply and sanitation such as sewerage systems improved health conditions in the urban areas (e.g. Hassan 1985, Szreter 1988, Bell & Milward, Chapman 2019, Harris & Hinde 2019), and medical services tended to expand more rapidly in cities and large towns than in rural areas (e.g. Lucey & Crossman 2014). As a result, from the final decades of the nineteenth century onwards the gap between urban and rural heights

[2] This also contributes to explaining why life expectancy at birth in cities above 100,000 inhabitants in England and Wales was lower and did not converge with the country's average in the first decades of the nineteenth century (Szreter & Mooney 1998).

closed or simply vanished and, finally, urban populations became taller than their rural counterparts (e.g. Komlos & Baten 2004; Tassenaar 2019, Groote & Tassenaar 2020).

This general account of an urban height penalty reversing into an urban height premium was, nevertheless, far from universal. For eastern Belgium, Alter, Neven and Oris (2004) found that urban-born men remained taller than their rural counterparts throughout the nineteenth century. Twarog (1997) reached similar conclusions by comparing rural areas and small towns in the southern German territory of Württemberg. Also in Germany, Baten (2009) concluded that in the first half of the nineteenth century "urban men were relatively tall in Bavaria", whereas "the areas near towns (…) [were] among the districts with lower average height", partially because the former drained food from the latter (Baten 2009: 175, see also Lantzsch and Schuster 2009: 50). For Switzerland, Schoch, Staub and Pfister (2012:160) argued that "no urban height penalty existed in 19th century Switzerland" and that "the conscripts from rural areas of canton Bern never have been taller than the conscripts from the city of Bern" in the cohorts of 19-year-old conscripts measured in the late nineteenth and the first half of the twentieth centuries.

In contrast, there is also evidence showing a permanent rural advantage relative to urban heights both in north-western Europe and in the US. For example, Riggs and Cuff (2013) reported a height advantage of about 2 cm in the rural cohorts born in late-nineteenth century Scotland by comparing rural and urban members of the military forces serving in World War I. Zehetmayer (2013) concluded that the cohorts of US soldiers born in rural counties between 1847 and 1890 were taller than those born in the 10 largest cities in the US or in the 90 next-largest cities (1.5 and 0.9 cm taller respectively). A rural height premium was also found in nineteenth-century Pennsylvania (Carson 2008). Nevertheless, Zehetmayer also observed that urban height converged over time: in the mid-nineteenth century "the best urban place to live in terms of height were small cities, while in the end of the nineteenth century, it was in larger cities with about 250,000 inhabitants, but not in the largest cities" (Zehetmayer 2013: 175).

The rural-urban gap is also found in nineteenth-and early-twentieth century southern Europe, and the Iberian Peninsula provides a good example of its complexity. With a lower per capita income and a shorter height than their north-western European counterparts (Hatton and Bray 2010), rural and urban dwellers in Iberia also presented height disparities. In Spain, aggregate country-level analyses show that young males living in provincial capitals and towns with more than 10,000 inhabitants were taller than their rural counterparts for the cohorts born in the last quarter of the nineteenth century, and that this situation continued at least until the birth cohorts of the 1920s (Quiroga 2001).

At regional level, the absence of an urban penalty is also found in south-eastern Spain in males born between 1837 and 1900. Yet, rural heights experienced a strong process of convergence towards the urban ones from this latter birth cohort to that of 1915 (Martínez-Carrión and Moreno-Lázaro 2007, see also Martínez-Carrión and Pérez-Castejón 1998 for particular towns). A similar picture applies to the Basque Country as far as the cohorts born between 1856 and 1915 are concerned.

In this latter case, however, the process of rural convergence began earlier and it was less intense than in south-eastern Spain (Martínez-Carrión, Pérez-Castroviejo, Puche-Gil and Ramon-Muñoz, J.M. 2014). Urban conscripts born in the central Spanish region of Castile-La Mancha were on average slightly taller than rural ones from the birth cohort of 1887 to 1933, and were able to widen their height advantage from then until the cohorts born in the early 1960s (Cañabate and Martínez-Carrión 2017). Similarly, the region of Extremadura presented a permanent rural height penalty for the birth cohorts of 1904 to 1954 (Linares Luján and Parejo Moruno 2013).

Portugal provides another example of urban heights being higher than rural heights, this time throughout the nineteenth century. The biological standard of living in Lisbon – a large city by European standards – was not lower than in the rest of the (mostly rural) country: conscripts from Lisbon were, in fact, slightly taller than those from outside the capital (Reis 2009).

While the absence of an urban height penalty seems to have prevailed in Iberia, this cannot be said of the protoindustrial and industrial areas. In the central region of Castile-Leon, rural and urban heights were roughly the same between the 1830s and the 1860s, but from then until the 1910s urban heights increased and intermittently surpassed rural heights (Martínez-Carrión and Moreno-Lázaro 2007, see also Hernández and Moreno-Lázaro 2011 for a more detailed analysis). More importantly, in the central decades of the nineteenth century, there were episodes of urban penalty in proto-industrial areas of Castile-Leon owing to the over-exploitation of the workforce and, in fact, between the birth cohorts of 1851-55 and 1861-65 urban conscripts became shorter than their rural counterparts (Martínez-Carrión and Moreno-Lázaro 2010). The same is found in the south-eastern industrial town of Alcoi, particularly for the cohorts born between the early 1860s and the late 1870s, and perhaps also in Antequera, a town in southern Spain, for the cohorts born in the third quarter of the nineteenth century (Puche and Cañabate 2016, for Alcoi, and Martínez-Carrión and Cámara 2015, for Antequera, see also Martínez-Carrión, Pérez-Castroviejo, Puche-Gil and Ramon-Muñoz, J.M: 2014). Height data for the Mediterranean region of Valencia also show that rural conscripts were between 0.5 and 1.0 cm taller than their urban counterparts. Although a process of convergence took place, in the first third of the twentieth century, inhabitants of rural irrigated areas remained taller than their peers in the cities (Ayuda and Puche-Gil 2014). Finally, in Catalonia, an urban height penalty was also found for the cohorts of males born during the first two thirds of the nineteenth century, but not for subsequent cohorts up until World War I (Ramon-Muñoz, J.M. 2009 and 2011). This pattern seems to have been more apparent in the industrial areas and in other more densely populated towns (Ramon-Muñoz, R. and Ramon-Muñoz, J.M. 2015, Ramon-Muñoz, R. and Ramon-Muñoz, J.M. 2016).

Owing to the diversity of the situations, categorical conclusions on the evolution of the rural-urban height gap are not easy to obtain. The presence (or absence) of an urban penalty, as well as its magnitude and its time course, is a contextual phenomenon that may differ both across countries and across regions. Moreover, it is a phenomenon that can be easily associated with the characteristics and intensity of industrialisation and its consequences on the biological standard of living of the population in the early stages of modern economic growth. This paper contributes to the well-established literature on industrialisation, living standards and urban-rural inequality in physical stature.

A second contribution made by this paper is to do with the data it uses and, partially as a result, with the approach it adopts. The currently available literature generally investigates the urban-rural gap based on samples consisting of a small number of villages, towns and cities.[3] Limited by the data and the samples used, many studies in this field also tend to follow a binary classification of population settlements: sites are simply classified as urban or rural, and no gradients in population size can be established. This study attempts to contribute to filling these gaps. It uses a large new dataset (comprising more than 16,000 observations) based on military records for the cohort of males born in the year 1890 and enlisted in the year 1911, at a time when (though some exceptions continued until one year later) universal compulsory military service was introduced (e.g. Molina 2012). The dataset has been designed to provide height evidence at individual level for each of the almost 950 current Catalan municipalities. This large geographical coverage represents a novelty with regard to previous studies. Our dataset also offers a clear advantage (as does the paper by Groote and Tassenaar (2020) for the province of Fryslàn, the Netherlands) over previous analyses by overcoming a dichotomic classification of territory into rural and urban, and, therefore, to test for linear (or non-linear) relationships between height and the size and economic nature of villages, towns, and cities.

The remainder of this paper is organised as follows. Based on primary and secondary sources, section 2 provides a brief overview of the evolution of biological living standards in nineteenth-century Catalonia. Section 3 presents the new dataset and some preliminary results. Section 4 applies an econometric model to test for the relationship between population size and biological living standards as well as to discuss the results of this test. Section 5 concludes by pointing out the existence of an urban premium in late nineteenth-century Catalonia.

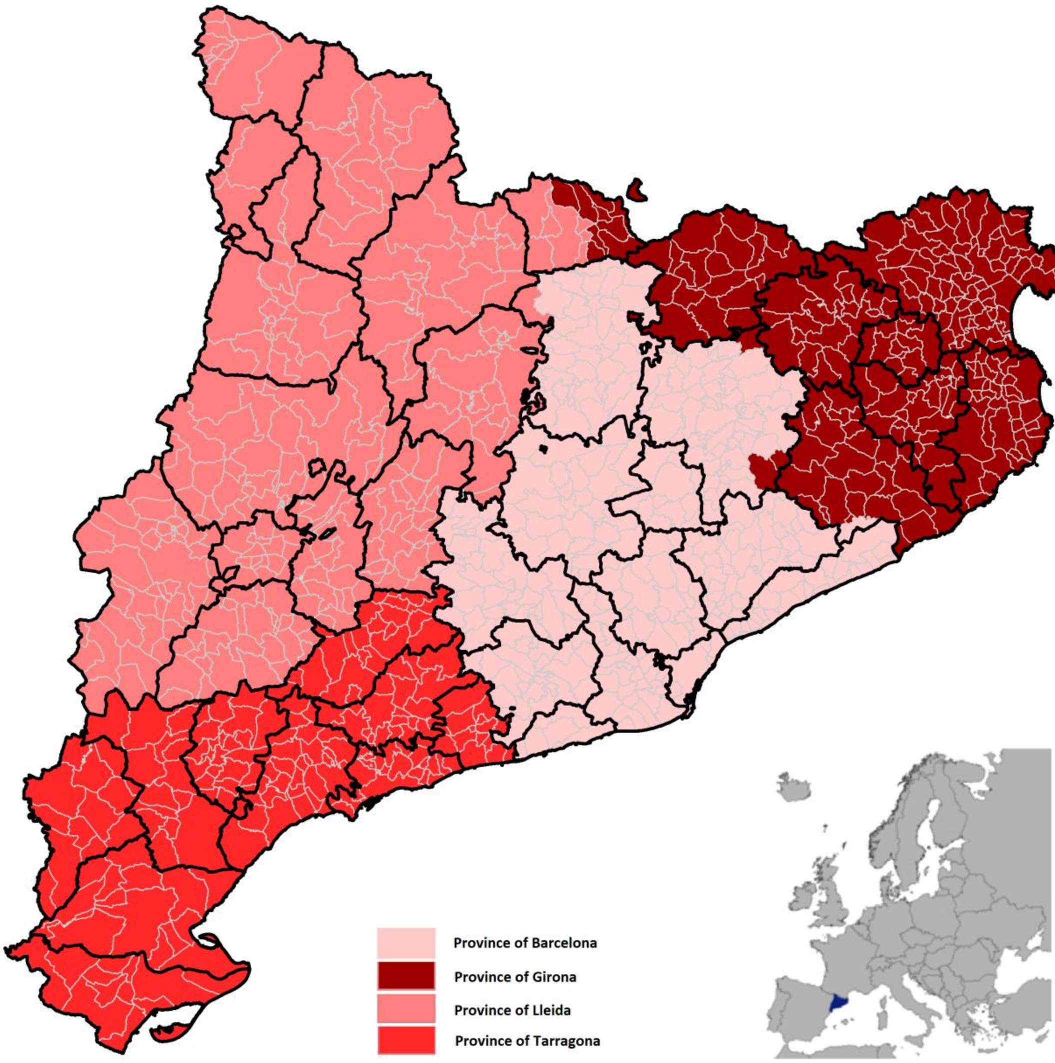
2. The evolution of biological living standards in nineteenth-century Catalonia: an overview

Catalonia underwent industrialisation unusually early compared with other regions on the European periphery (Pollard 1981). The origins and the development of Catalan industrialisation have been well researched. Initially, they were associated with the establishment of calico printing and, later on, with the progressive growth of cotton spinning and weaving (Sánchez 1989; Thomson 1992). Catalan industrialisation took a step forward in the early 1830s, when cotton manufacture began an intensive process of mechanisation and, partially as a result, the factory-system emerged (Nadal 1975; Sánchez, 1989). Between 1835 and 1850, the number of mule-jennies multiplied by a factor of more than 17, from 27,220 to 475,490 (Nadal 1975: 196). As modern manufacturing developed, industrial production expanded rapidly in Catalonia: in the 1830s it grew at annual rate of more than 7

[3] For the particular case of Spain, this applies to all the studies quoted with the exception of Quiroga (2001), who uses provincial samples.

per cent, and in the 1840s and 1850s this percentage was 5.4 and 5.7 per cent respectively (Maluquer de Motes 1994: 61, see also Carreras 1985).

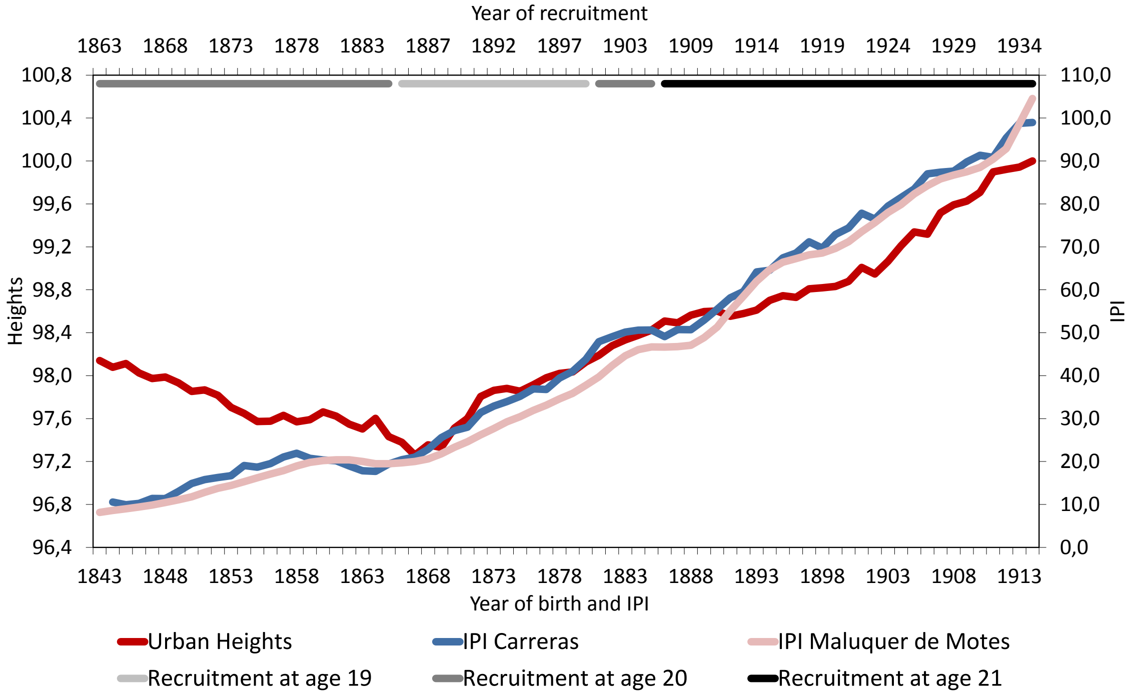
Figure 1
Map of Catalonia: provinces, counties and municipalities



Notes and sources: Based on Eurostat (http://epp.eurostat.ec.europa.eu) and Municat (http://municat.gencat.cat).

Did industrial and economic growth influence biological living standards? In the United Kingdom, and in other north-western European countries, the early stages of modern economic growth coincided with a decline in heights, giving rise to the so-called "early-industrial growth puzzle" (e.g. Komlos 1998). The estimates by Cinnirella (2008) show, for example, that in Britain the mean height of a young man aged 18 years declined by around 4 cm during the second half of the eighteenth century and by around 3 cm during the 1820s and the 1840s.

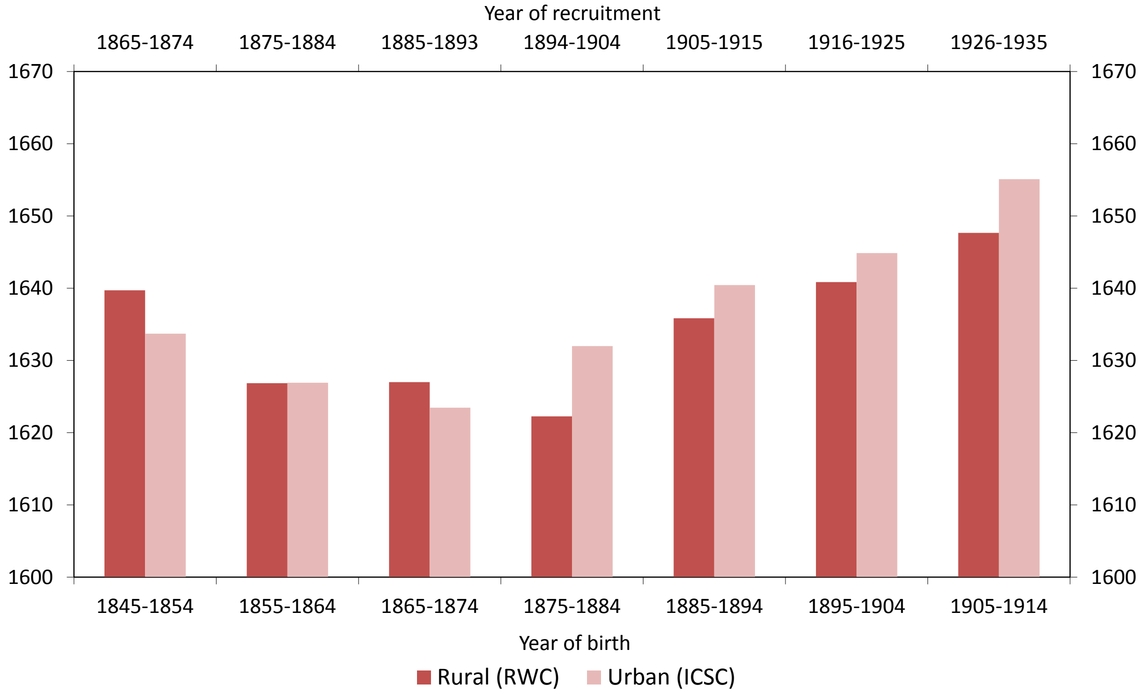
Figure 2
Industrial Production Index (IPI) and Urban Heights trend in Catalonia, 1840-1914 (five-year moving averages, 1914=100)



Notes and sources: Based on data from Carreras (1985), Maluquer de Motes (1994) and Appendix, Table A1.

In Catalonia, there is also some evidence of an "early-industrial growth puzzle". The case of Igualada, a medium-sized industrial town in the centre of the country, is illustrative in this respect. Around the middle of the nineteenth century, the town's economy experienced rapid growth due mainly to the expansion of the cotton industry. Large new factories were built and by the 1840s Igualada and its surrounding area had become Catalonia's largest cotton centre, in terms of the numbers of both workers and spindles. However, at the time that this local economy was emerging as a factory-based industrial centre and was attracting immigration, the mean height of the males dropped. In particular, the mean height of the cohorts of conscripts born in Igualada between the 1830s and the 1860s decreased by more than three centimetres, from around 165 cm to around 162 cm. The data presented in Figure 2 suggest that the pattern seen in Igualada can be extended to other towns and, perhaps, to the whole of industrial Catalonia, at least for the cohorts born between the early 1840s and the early 1860s. Interestingly, put in the Iberian context, the fall in the Catalan urban male heights during the early stages of industrialisation was something of an exception (Ramon-Muñoz, R. and Ramon-Muñoz, J.M. 2015, Ramon-Muñoz, R. and Ramon-Muñoz, J.M. 2016).

Figure 3
Heights of conscripts from rural and urban Catalonia in the nineteenth and early twentieth centuries
(in millimetres)

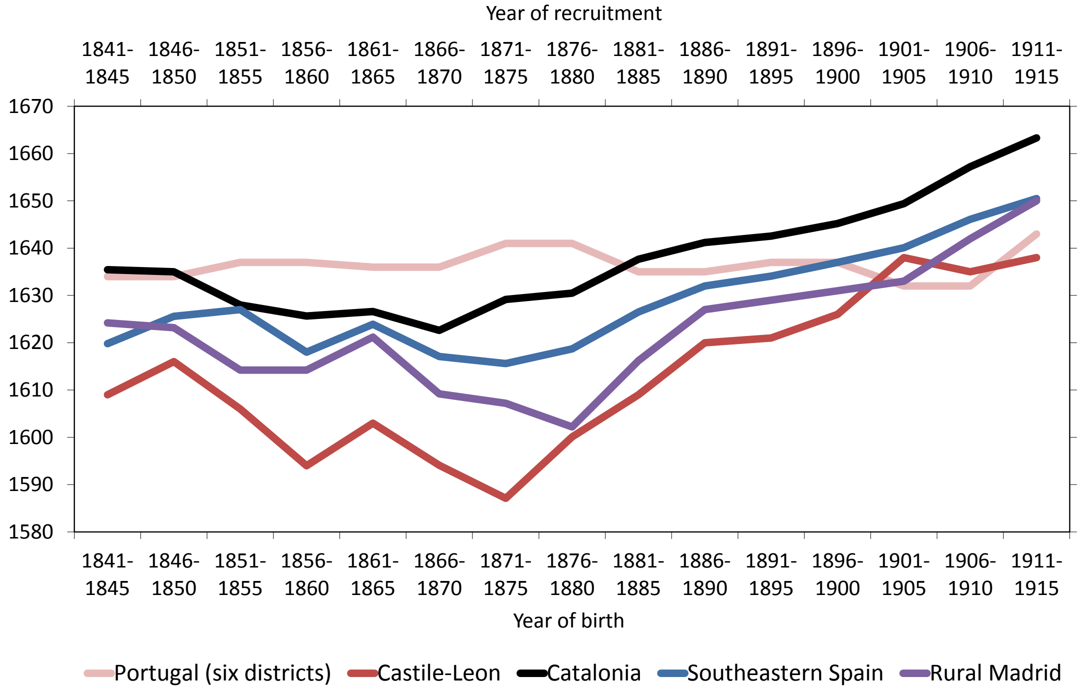


Notes and sources: See Appendix, Table A1. Rural and urban data refer to Rural Western Catalonia (RWC) and to Industrial Central & Southern Catalonia (ICSC) respectively.

With urban male heights declining between the 1840s and the 1860s, one might expect the emergence of an urban penalty in Catalonia. Indeed, this is what the data displayed in Figure 3 suggest. By the early 1840s, Catalan rural conscripts were already taller (+ 0.6 cm) than their urban counterparts (t=-1.899; p=0.058). As Figure 3 shows, rural heights dropped after the 1840s, paralleling the urban trend. The duration of this declining period was, nevertheless, restricted to the decade of 1850 and contrasts with the evolution of urban heights; in this latter case, reductions in physical stature were permanent and lasted until the 1860s. By then, rural conscripts were again taller (+ 0.5 cm) than their urban peers (t=-1.810, p=0.070).

A new cycle in the evolution of Catalan heights emerged in the last third of the nineteenth century. With regard to urban heights, Figure 3 shows an increase of more than 3 cm for the cohorts born between the 1860s and the early 1910s. The possible explanations for this remarkable improvement are discussed in Section 1. Nevertheless, one might also suggest that it was precisely during the last third of the nineteenth century when the expected productivity gains derived from industrialisation began to be distributed more equally. In the industrial town of Igualada, for example, height inequality (measured using the coefficient of variation) increased throughout the third quarter of the nineteenth century; however, it fell sharply over the following years, a period in which the mean height also began to rise (Ramon-Muñoz, R. and Ramon-Muñoz, J.M. 2015, Ramon-Muñoz, R. and Ramon-Muñoz, J.M. 2016).

Figure 4
Mean male height trends in Iberia, 1840-1914
(in millimetres)



Notes and sources: For Portugal, height data include six Portuguese districts and are only available for the cohorts born in 1840, 1850, 1860, 1870, 1880, 1890, 1900 and 1910. Original data for Levante refer to the following periods: 1840-1844, 1845-1849, 1850-1854. Based on data from Cámara, Martínez-Carrión, Puche and Ramon-Muñoz (2019), García Montero (2009), Martínez-Carrión and Moreno-Lázaro (2007), Puche-Gil (2011), Ramon-Muñoz, J.M. (2009, 2011, updated data), Ramon-Muñoz, R. and Ramon-Muñoz, J.M. (2016) and Stolz, Baten and Reis (2012). We exclude from the sample regions with samples comprising fewer than five municipalities as well as regions for which data are not available.

If urban heights evolved positively, there is also evidence that in Catalonia the heights of the cohorts of rural conscripts born from the 1870s onwards followed a similar pattern (see also Ramon-Muñoz, R. and Ramon-Muñoz, J.M. 2018 for the long-term evolution of biological living standards in rural Catalonia). Although the causes of the emergence of a positive trend in rural heights require further analysis, there is evidence of a positive association between rural heights and rural wages for the cohorts born between the mid-1890s and the early 1910s. A similar association may be established when agricultural production and land productivity is taken into consideration (Ramon-Muñoz, J.M. 2009).

The improvement of Catalan heights in both urban and rural areas had an important consequence: the emergence of Catalonia as one of Iberia's leading regions in terms of biological living standards. On the eve of World War I, the mean height of the male cohorts born at that time was 166 cm in Catalonia, compared with 165 cm in the regions of Valencia, rural Madrid and south-eastern Spain, 164 cm in Portugal and 163 cm in Castile-Leon (Figure 4).[4] At that time,

[4] Additional evidence confirms Catalonia's height leadership observed in Figure 4 for male cohorts born some years before the outbreak of World War I, at least as far Spain is concerned. In contrast, for the cohorts born in the late nineteenth century the available evidence is less conclusive. See

Catalonia had already become "Spain's factory" and was also the Spanish region with the highest GDP per capita (Nadal 1985, Parejo 2001, Díez-Minguela, Martínez-Galarraga, and Tirado 2018, Wolf and Rosés 2020).

Interesting as it may be, this account of the evolution of biological living standards in nineteenth-century Catalonia needs to be complemented. The cycle of growth in Catalan heights that began in the late 1860s went hand in hand with a reversal in the urban penalty. In fact, by the last quarter of the nineteenth century urban heights were above rural ones and continued so for the next four decades. The available evidence suggests, therefore, that during the second half of the nineteenth century the urban-rural height gap in Catalonia evolved from an urban height penalty to an urban height premium. Unfortunately, the Catalan data upon which this interpretation depends are still quite fragmentary, based on five rural municipalities and three industrial towns, which means that the currently available dataset covers a very low percentage of the Catalan geography. In order to fill this gap, a new dataset has been constructed. The next section describes its main features as well as its potential shortcomings.

3. A unique new dataset on heights in late nineteenth-century Catalonia

The dataset used in this paper is based on military records generated during the enlistment process for military service in early twentieth-century Spain. In particular, mainly due to data availability, the information we collected refers to the recruitment year of 1911, which corresponds to the birth cohort of 1890. For this cohort, legal exemptions still prevented a certain number of young males from effectively joining the army. These exemptions were in force until 1912 (thus affecting the cohort of 1891), when a new law was enacted (e.g. Molina 2012). In practice, however, the recruitment and enlistment process for the birth cohort on which our data relies was universal and compulsory. In 1911, all 21-year-old men were called up for military service and inspected.[5] It is important to stress this point, since it shows that our study sample is minimally affected (if at all) by the potential biases suggested by the literature (Komlos 2004, Bodenborn, Guinnane, Mroz 2017, Schneider 2020).

A first step in the recruitment and enlistment process involved measurement and medical inspection, which was conducted at local level. The authorities of every single municipality had to prepare local lists of recruitment, the *Actas de Clasificación y Declaración de Soldados* (Acts of Classification and Declaration of Soldiers), which included, among other data, the name, birth year, and the physical stature of the draftees. Based on height measurements and other additional information, local boards established whether or not conscripts were fit to serve.

The second step in the process took place at provincial level (Cámara, 2006). The Recruitment and Replacement Act of 1896 established the creation of examination commissions in the provinces, known as the *Comisión Mixta* (Mixed Commission). These commissions were designed to rule on applications made by the draftees to

Quiroga (2001) and (2002), Gómez Mendoza and Pérez Moreda (1985), and Martínez-Carrión, Cámara and Pérez-Castroviejo (2016).

[5] In fact, exemptions from military service were made effective once the enlistment process ended (Nicolau and Fatjó 2016).

be excused from obligatory military service. The information collected in both the local and the provincial recruitment rounds was summarised in the *Libros de Reemplazo* (Recruitment Books).

A third step in the process took place once the inspection procedure had finished. All conscripts fit to serve were included in a local lottery, a public event designed to select the conscripts who would finally join the Spanish army. The exact number of conscripts selected varied from one year to another, depending on the army's requirements. The number was established at the beginning of each year by the Spanish government, which then distributed the required number of conscripts by provinces and in accordance with the population of each province. Then, the provincial authorities did the same and, therefore, established the corresponding distribution at municipal level. In any case, the provincial authorities were asked to send the Ministry of War detailed information about each conscript who was finally to join the army (Molina 2012). This information was summarised in the *Hojas de Filiación de los Expedientes Reglamentarios de Tropa* (Registration Records from the Troops' Statutory Files).

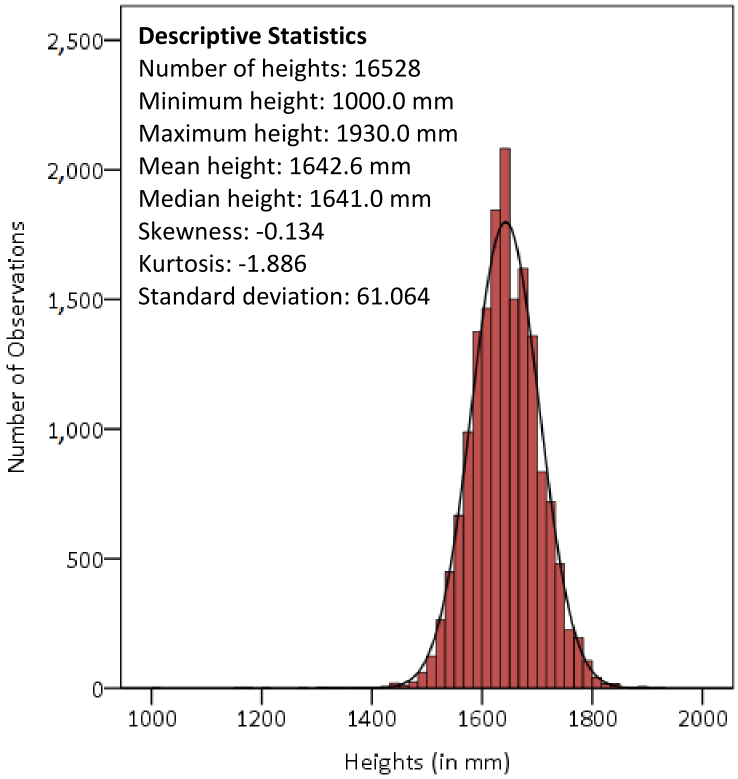
Table 1
Number of conscripts and Municipalities included in the current dataset

Province	Total conscripts	Conscripts with height data	No. of municipalities	
			province	dataset
Barcelona	10,076	9,004	314	299
Girona	3,135	3,011	223	212
Lleida	3,200	2,763	227	224
Tarragona	1,774	1,750	184	174
Total	18,185	16,528	948	909

Notes and sources: See text.

Our dataset uses height data originating from each of the phases that made up the conscription process. Thus it comprises information collected from the Acts of Classification and Declaration of Soldiers, the Recruitment Books, and, finally the Registration Records from the Troops' Statutory Files of the conscripts enlisted in the recruitment year of 1911. In total, we use information from 18,185 individuals and height data from 16,528 (Table 1). The difference between these two figures is related to several factors. Although all young men were called up for military service, some of the draftees deserted before inspection and, so height information is lacking for some individuals. In addition, some conscripts were living outside their official places of residence at the time of enlistment, and so they were not always able to respond to the call of the local or provincial authorities. Finally, inaccuracies and changes in the criteria used in the registration process might have prevented us from using a larger set of height data. Nevertheless, the dataset we have constructed is able to cover a very large percentage of the cohort of men born in 1890 and living in Catalonia in 1911. In fact, the mean heights of this birth cohort differ little from most of the available estimates (Appendix, Figures A1 and A2 respectively), which are based on aggregate data (Gómez Mendoza & Pérez Moreda 1985) or on smaller samples (Ramon-Muñoz, J. M. 2011).

Figure 5
Distribution of heights of Catalan conscripts and descriptive statistics
(male cohort born in 1890 and enlisted in 1911)

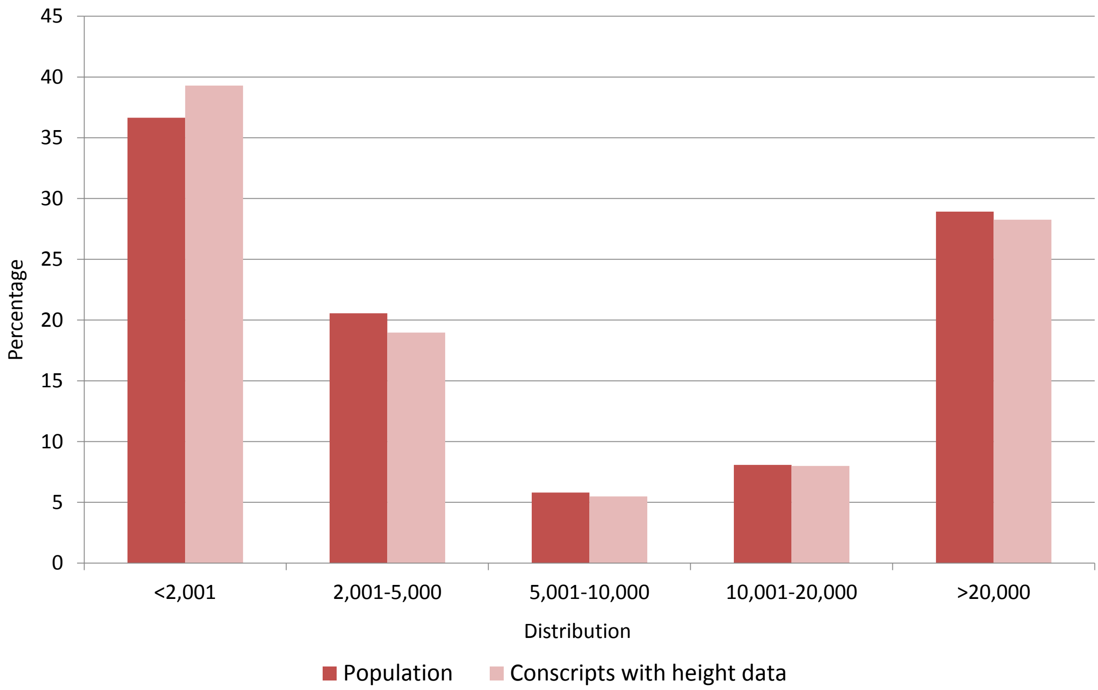


Notes and sources: See text.

So are the heights in our dataset normally distributed? Figure 5 suggests that the answer is affirmative. More precisely, it shows that our data follow a quasi-normal (Gaussian) pattern, with a negative skew due to the existence of several extremely low heights which are not necessarily explained by measurement errors. Figure A3 provides evidence of the distribution of the height data at provincial level (see Appendix). Finally, and very importantly, the distribution presented in Figure 5 also suggests that our dataset is not affected by truncation, one of the main potential shortcomings in military samples (e.g. Komlos 2004). This makes the dataset we use for late nineteenth-century Catalonia something of an exception compared to other height samples used in the international anthropometric literature.

Our dataset covers a large percentage of the male cohort born in 1890 and living in Catalonia in 1911, and it also has a broad geographical range, including data for 909 out of the 948 present-day municipalities in Catalonia (Table 1). In other words, the municipalities covered by this dataset account for 99.6 per cent of the population residing in Catalonia around 1890. Even more interestingly, perhaps, the distribution of both sets of conscripts fits extraordinarily well to the distribution of population by municipality size as measured by the number of inhabitants (Figure 6). To be sure, the geographical coverage of the dataset used in this study represents a novelty with regard to other datasets available for Iberia as well as for some other European countries and regions. For example, the largest dataset for nineteenth-century Iberia has been constructed for the region of Castile-Leon (Hernández García and Moreno Lázaro 2009 and 2010), including almost 68,000 observations for the male cohorts born between 1839 and 1915. It takes into account the largest towns in the region as well as a considerable number of rural areas. For obvious reasons, however, the total number of localities included in this dataset is limited: namely, 25 localities out of the 2,248 municipalities that currently make up the region of Castile-Leon.[6]

Figure 6
The distribution of conscripts and population by population size of the municipalities in Catalonia
(male cohort born in 1890 and enlisted in 1911)



Notes and sources: See text.

Of course, the dataset that we developed is not without certain limitations. Firstly, we do not have information on the place of birth for most of the conscripts, only on the place of residence. This is simply because places of birth are not specified in most of the data sources at our disposal. Therefore, we had to arrange conscripts' heights by municipality of residence at the time of enlistment rather than by municipality of their birth. What is more, we did so using present-day municipal boundaries. As will be explained below, this point has to be taken into account when interpreting the results, particularly regarding the municipalities in the province of Barcelona (Table 2). Nevertheless, the data reported by the Spanish Population Census of 1910 show that for the rest of the Catalan provinces, i.e., Girona, Lleida and Tarragona, more than 90 per cent of the inhabitants resided in the same province (and perhaps locality) as the one in which they had been born.

[6] Certainly, there are other broad datasets in Iberia, although they are not always designed to search for the existence of a rural-urban height gap. The datasets that include a large number of localities refer to Extremadura (35 localities, cohorts of males born from 1855 to 1979), rural Catalonia (102 localities, cohorts of males born from 1879 to 1896) and rural Madrid (18 localities, cohorts of males born from 1837 to 1915). See Linares Luján and Parejo Moruno (2021), Ramon-Muñoz, R, Ramon-Muñoz, J.M., and Koepke (2015) and García Montero (2009), respectively. In contrast, the database with the largest number of observations (n=358,253) with male cohorts born between 1840 and 1964 includes only 19 localities. See Cámara, Martínez-Carrión, Puche, and Ramon-Muñoz J.M. (2019).

Table 2
Distribution of the Catalan population by place of birth, 1910 (percentages)

Province	In the same province	In other provinces	Abroad	Unknown
Barcelona	72,53	26,27	0,85	0,34
Girona	91,82	7,39	0,79	0,00
Lleida	94,50	5,04	0,35	0,12
Tarragona	93,58	6,22	0,20	0,01
Total	81,91	17,22	0,67	0,21
Barcelona*	58,22	39,85	1,36	0,57

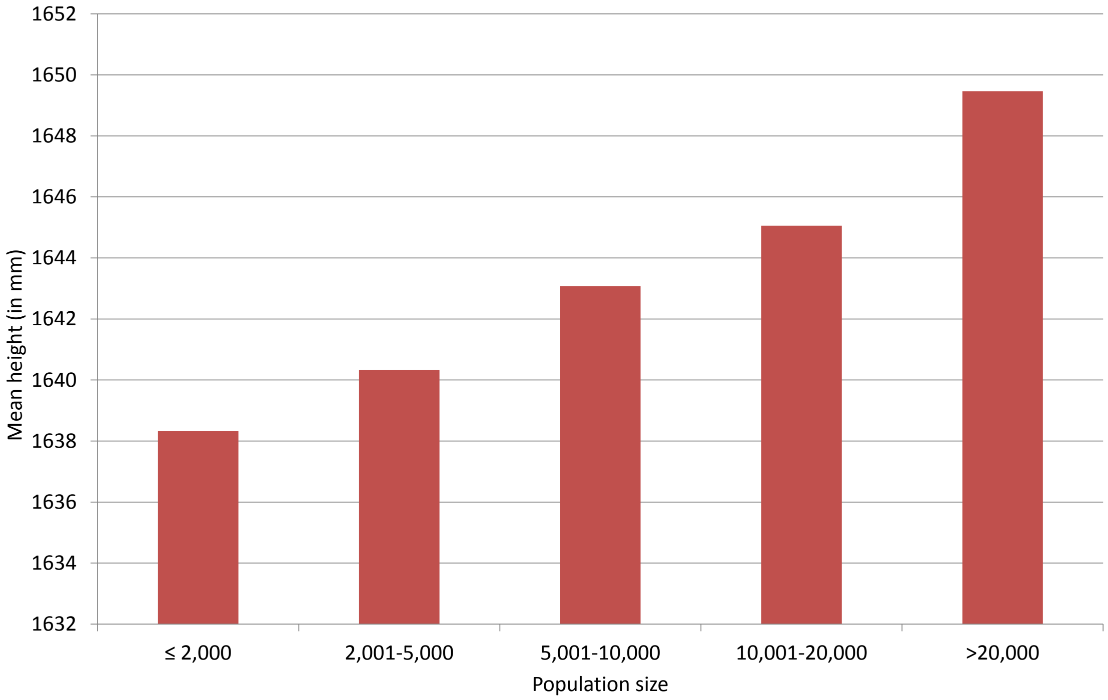
Notes and sources: (*) City of Barcelona. Based on data from the Population Census of 1910.

Secondly, during the process of data collection we noticed that for certain localities the information available on conscripts' heights might be affected by censuring. In these cases, the sources we used offered no information on the stature of the conscripts below 1540 mm, which was the minimum height required to join the army at that time. However, the sources did detail the number of conscripts below the minimum stature required. While they were mostly concentrated in the province of Barcelona, the number of records affected by censoring was fortunately quite low: 56 out of 16,584 records. We did not include these records in our dataset.

Thirdly, we were particularly concerned about the potential incompleteness (and the resulting lack of representativeness) of the height data for the municipalities located in the southern Catalan province of Tarragona. For these municipalities, we had to mainly rely on the data included in the Registration Records from the Troops' Statutory Files. This source only records information for the conscripts who finally joined the army. Therefore, we foresaw a low number of draftees per municipality and, most importantly, a lack of conscripts with a stature below the required minimum height, namely 1,540 mm.

Fortunately, our concerns are not confirmed. Although we do indeed find a lower number of observations in the Registration Records than in other sources, we find short conscripts serving as soldiers as well as a quasi-normal distribution of heights (see Appendix, Figure A3). Conscripts below the minimum height accounted for about 2.6 per cent of total provincial heights, a figure not far below that found in other provinces (3.6 per cent) (see Appendix, Figure A4). In fact, when we compare data from different sources we obtain similar results. To give an example, in the city of Reus – the largest urban concentration in the province of Tarragona and the second most populated city, after Barcelona, in late nineteenth-century Catalonia – the cohort of males born in 1890, and residing in the city in 1911, was 1,648.5 mm tall (n=185). This result was obtained by using local data from the Acts of Classification and Declaration of Soldiers. If, instead of this source, we use data from the abovementioned Registration Records the mean height for Reus would be 1,650.8 mm (n=95), namely a difference of 2.3 mm (see also Appendix, Figure A5 for a comparison of the distributions in these two datasets).

Figure 7
The mean height of conscripts by population size of the municipalities in Catalonia (in mm)
(male cohort born in 1890 and enlisted in 1911)



Notes and sources: See text.

To sum up, in spite of these limitations, we believe that the dataset we developed is reliable and able to produce robust, non-biased and valuable results on the relationship between population size and biological living standards. One of these results is shown in Figure 7, which suggests a positive, linear relationship between height and population size. As the conscripts residing in municipalities with fewer than 5,001 inhabitants were shorter than the rest, the data seem also to support the existence of an urban premium (and a rural penalty) in late nineteenth-century Catalonia. Interesting as it is, the picture emerging from Figure 7 is, nevertheless, far from being conclusive; and it is through the use of quantitative methods that we may assess the robustness of our findings.

4. Testing for the relationship between population size and height: model and results

This section aims to test the relationship between population size and height. It analyses whether (and if so, to what extent) econometric analysis confirms the late nineteenth-century urban premium, and the positive linear relationship between population size and height suggested in sections 2 and 3. To this end, we apply a model that uses cross-sectional data and is based on ordinary least squares (OLS), summarised in Equation (1).

$$(1)\ \ HEIGHT_{ji} = \beta_0 + \beta_1\ CATMUNPOPSIZE_{ji} + \beta_2\ Z_{ji} + \mu_{ii}$$

In this model, the dependent variable is the height of most of the young Catalan males who were called up for military inspection in the 1911 draft. As previously explained, they were born in 1890 and were measured and enlisted at the age of 21. The total number of conscripts with height data is set at 16,528, belonging to 909 municipalities. In equation (1), the notation $HEIGHT_{ji}$ thus refers to the height of the recruit *j* residing in municipality *i* born in 1890. The other variables included in the model are $CATMUNPOPSIZE_{ji}$ and Z_{ji}. $CATMUNPOPSIZE_{ji1887}$ is the main independent variable. It refers to the category of municipality *i* (by population size in the census year of 1887) where the recruit *j*, born in 1890 and inspected in 1911, officially resided at the time of enlistment. The variable Z_{ji} designates a series of controls, namely population density, presence/absence of a railway station, literacy rate, and altitude of the municipalities where the given conscript resided, and, finally, the error term μ_{ji}.

Regarding the independent variables included in the econometric model, there are two preliminary issues that need to be mentioned. Firstly, the independent variables we use always refer to the period around the year of birth of the conscripts. This decision has a simple explanation: in line with most studies in anthropometric history, we assume that the stature of the 21-year-old Catalan conscripts was influenced most by environmental and nutritional factors during the conscripts' first years of life rather than during their teenage years (e.g. Tanner 1978, Van Zanden et al. 2014, Gao and Schneider 2021, Schneider 2020).

Secondly, due to limitations in the data sources, the independent variables included in the econometric analysis are variables at municipal level. This means that we link the individual height information for each of the 16,528 conscripts that form our dataset with some factors characteristic of the 909 municipalities where the given conscript officially resided at the time of military inspection. Unfortunately, as mentioned in the previous section, limitations in data sources also prevent us from having precise information on the localities where the conscripts were born and lived during their early childhood.

Bearing all this in mind, we have constructed four different independent variables to be included in the model. The main variable of interest is the population size of the municipality where conscripts in question resided when they were measured and enlisted. Population data have been taken from Spain's population census of 1887, which is the closest census to the birth cohort of 1890. In line with other studies (e.g. Heyberger 2014, Zehetmayer 2013), we have constructed several categories of municipalities in order to take account of municipal population size. These categories are: below 2,000 inhabitants, between 2,001 and 5,000 inhabitants, between 5,001 and 10,000 inhabitants, between 10,001 and 20,000 inhabitants, and more than 20,000 inhabitants. The first two categories can be considered as coming clearly under the definition of rural areas (Gómez-Mendoza and Luna-Rodrigo 1986), whereas a definition for the remaining groups is more difficult to establish. In late nineteenth-century Catalonia, municipalities between 5,001 and 20,000 inhabitants might be defined as towns of different population sizes, even if some scholars would perhaps prefer to include them under the category of rural areas. Finally, municipalities with more than 20,000 inhabitants conform clearly to the definition of urban areas and, in some cases, they might be defined as industrial cities. These five categories of municipalities have entered into the regression as dummy variables (e.g., if the conscript resides in a municipality of fewer than 2,000 inhabitants 1, otherwise 0). Descriptive statistics suggest a positive relationship between population size and height.

Population size of the municipalities is the main variable of interest, but we also consider other potential factors that might affect the stature of the young Catalan males called up for military service. These factors are included as controls in the regression. The first (and perhaps obvious) variable we take into consideration is population density. Certainly, this variable is highly (and positively) correlated with population size (Table 3). Nevertheless, population size is included in the regression as a categorical variable, and, in the end, population density may contribute to capturing the potential (negative) impact of overcrowding on biological living standards, as discussed above in the introduction. Population data have again been taken from Spain's population census of 1887. As we use the current municipal boundaries, we have taken information on municipal areas from the Statistical Institute of Catalonia (IDESCAT) for 2021.[7]

The second variable of control included in our regression aims to measure access to railway transport and, therefore, market integration. There is a large body of literature that shows that the railway had an influence on heights. On the one hand, this influence tends to be positive in the case of urban dwellers since railways facilitated the transport of foodstuffs from rural to urban areas. As a result, foodstuffs became cheaper and more abundant in towns and cities, a circumstance that may well have helped to improve the nutrition of urban dwellers (e.g. Solakoglu 2007, Yoo 2012, Zehetmayer 2013). However, railways might be detrimental to the biological living standards of the rural population. Firstly, they might facilitate the spread of diseases from cities to rural areas, and secondly, they might contribute to depriving country-dwellers of proteins and other nutrients, thus negatively affecting the height of rural communities (e.g. Komlos 1987, Haines 1998, Haines et al. 2003, Haines 2004). In order to capture these potential impacts, we have constructed a dummy variable that states whether the conscript in question resided in a municipality with a railway station or not (1 and 0, respectively). Using data provided by Pascual (2016: Appendixes) as well as other complementary information, this variable only considers the municipalities that had a station in broad gauge railway lines in 1890, coinciding with the year of the conscripts' birth. In that year, the railway lines with broad gauge accounted for more than 90 per cent of all railway lines operating in Catalonia (Pascual 2016: 27-30).

The third control variable we take into consideration is literacy rate. While literacy is considered a proxy for human capital, it also reflects differences in socioeconomic status between individuals. The anthropometric literature has generally suggested a positive relationship between literacy and height, with literate males being significantly taller than the illiterate ones (e.g., Ayuda & Puche 2014, Palma & Reis 2021 for Iberia). Unfortunately, we are only able to capture literacy rates at municipal level. This means that our data provide information on the percentage of the population able to read and write in the municipality in which the conscript resided, but not on the literacy of the individual draftee. Again, we use data referred to the closest birth year of the conscript, namely local literacy rates taken from Spain's population census of 1887. Bivariate correlations suggest a

[7] See http://www.idescat.cat/en/ (last accessed July 5, 2021).

positive and statistically significant relationship between literacy rates and height in late nineteenth-century Catalonia (Table 3).

Table 3
Matrix of correlations for continuous variables

	Height of individuals (birth cohort 1890)	Population size of municipalities (1887)	Population density of municipalities (1887)	Literacy rate (1887)	Altitude of municipalities
Height of individual (birth cohort 1890)	1.000				
Population size of municipalities (1887)	0.064	1.000			
Population density of municipalities (1887)	0.066	0.995	1.000		
Literacy rate (1887)	0.072	0.705	0.736	1.000	
Altitude of municipalities	-0.097	-0.469	-0.492	-0.526	1.000

Notes and sources: * All results are statistically significant at the 1 percent level. See text.

The last control variable we consider in our econometric model is the altitude of the municipalities where the conscript was officially residing at the time of inspection. This variable, which we have taken directly from IDESCAT, has been considered in several studies on biological living standards. For example, in Argentina Bejarano et al. (2009) found a negative relationship between mean height and geographical altitude in a sample of 48,589 conscripts born between 1870 and 1960. By reviewing the findings of a Portuguese physical anthropologist, Da Costa Leite (1998: 460) observed that in the 1890s men were "shorter in the areas of higher altitude" of Northern Portugal. Ramon-Muñoz, R., Ramon-Muñoz, J.M. and Koepke (2015) arrived at similar conclusions for late nineteenth-century western Catalonia using a sample of 16,389 conscripts born between 1879 and 1890. This negative association between stature and altitude might reflect a number of factors, including, among others, climatic conditions, agriculture orientation, poor economic conditions in highlands, transport costs, isolation, as well as difficulties in accessing to richer and more abundant resources. In addition, altitude is also correlated to other variables that might negatively affect height. In our dataset, and as expected, it is significantly and negatively correlated with population size and population density (Table 3). However, in both cases the R^2 is not as strong as one might have expected (around 0.25). Interestingly, the matrix of correlations presented in Table 3 also shows a negative relationship between altitude and height, while, as suggested above, height correlates positively with both population density and population size.

Finally, we also add territorial dummy controls to some of the specifications in our model. We consider that the territories where the conscripts lived differed in some unobservable way that might affect our dependent variable. Based on the information provided by the IDESCAT, we have considered eight different territorial areas: Alt Pirineu i Aran, Camp de Tarragona, Comarques Centrals, Comarques Gironines, Àmbit Metropolità de Barcelona, Penedès, Ponent, and Terres de l'Ebre.[8] While these areas include quite homogeneous counties, they also differ one from each other geographically as well as economically. This internal homogeneity combined with heterogeneity across territories would have been more difficult to identify if we had used dummies at provincial level.

Table 4
The impact of population size on male heights in Catalonia in the cohort born in 1890
(Dependent variable: Individual male height, mm)

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Population Size:						
≤2,000 inhabitants	-11.144***	-10.574***	-10.639***	-9.710***	-6.304***	-6.190***
	(0.951)	(2.026)	(2.118)	(2.128)	(1.829)	(2.155)
2,001 - 5,000 inhabitants	-9.178***	-8.620***	-8.547***	-8.565***	-6.883***	-6.852***
	(1.307)	(2.166)	(2.268)	(2.237)	(1.860)	(2.161)
5,001 - 10,000 inhabitants	-6.217**	-5.684	-5.118	-5.964*	-4.821	-5.100
	(3.055)	(3.482)	(3.619)	(3.511)	(3.415)	(3.590)
10,001 - 20,000 inhabitants	-4.408	-3.923	-4.671	-6.035	-4.803	-4.324
	(3.206)	(0.000)	(3.768)	(4.126)	(3.479)	(3.590)
> 20,000 inhabitants	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Population density		0.000	-0.000	-0.001	-0.001*	-0.001
		(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
Railways station			2.847*	1.912	-0.056	-0.508
			(2.178)	(1.126)	(1.537)	(1.761)
Literacy rate				0.176**	0.103	0.139
				(0.088)	(0.083)	(0.091)
Altitude					-0.017***	-0.017***
					(0.003)	(0.004)
Dummies at territorial level	No	No	No	No	No	Yes
Constant	1,650***	1,649***	1,647***	1,642***	1,649***	1,646***
	(0.282)	(1.843)	(2.178)	(3.047)	(2.813)	(4.567)
R-squared	0.006	0.006	0.006	0.007	0.011	0.012
Observations	16,528	16,528	16,528	16,528	16,528	16.528

Sources and Notes: *** p<0.01, **p<0.05, *p<0.10. Clustered robust standard errors in brackets.

Table 4 presents different specifications of the model. The results indicate a positive and statistically significant association between male heights and population size, although this significance is not universal in all municipality categories. In the absence of control variables, this association is statistically significant in the three first categories, namely up to 10,000 inhabitants (Table 4, Column 1). Relative to the conscripts that resided in cities with more than 20,000 inhabitants, which is the reference category, residents of these areas were -6.2, -9.2 and -11.2 mm shorter, depending whether they lived in small towns (5,001 - 10,000 inhabitants) or in larger (2,001 - 5,000 inhabitants) and smaller villages (less than 2,001 inhabitants) respectively.

The addition of control variables to the basic regression does not change the direction of the association between population size and height. However, coefficients and their statistical significance tend to vary. First, the linear relationship observed between population size and height, at least for the categories

[8] See https://www.idescat.cat/codis/?id=50&n=28 (last accessed July 5, 2021), and Appendix, Figure A6.

of municipalities of up to 10,000 inhabitants, simply vanishes. This is particularly notable when, in addition to population density, presence of a railway station, and literacy rate, we also control for the municipalities altitude.[9] In early nineteenth-century England and Wales, Humphries and Leunig (2009: 468) found that population became a significant (and negative) determinant of height only in towns with a population of more than 8,000 inhabitants, and particularly in big cities. In the United States, Zehetmayer (2013: 175) found an inverse U-shaped relationship in which height reaches its maximum value in cities with about 250,000 inhabitants and then declined thereafter for the cohorts born in late nineteenth century. In Catalonia, we find no substantial differences in height between the residents in villages of up to 2,000 inhabitants and those living in municipalities between 2,001 and 5,000 inhabitants, probably because these localities shared a rural environment, and differences in physical stature are mainly explained by factors other than population size. Perhaps more surprisingly, we also find no statistically significant differences in height in the draftees living in municipalities between 5,001 and 20,000 inhabitants relative to our reference group. Clearly, these results point to the absence of a linear relationship between population size and height.

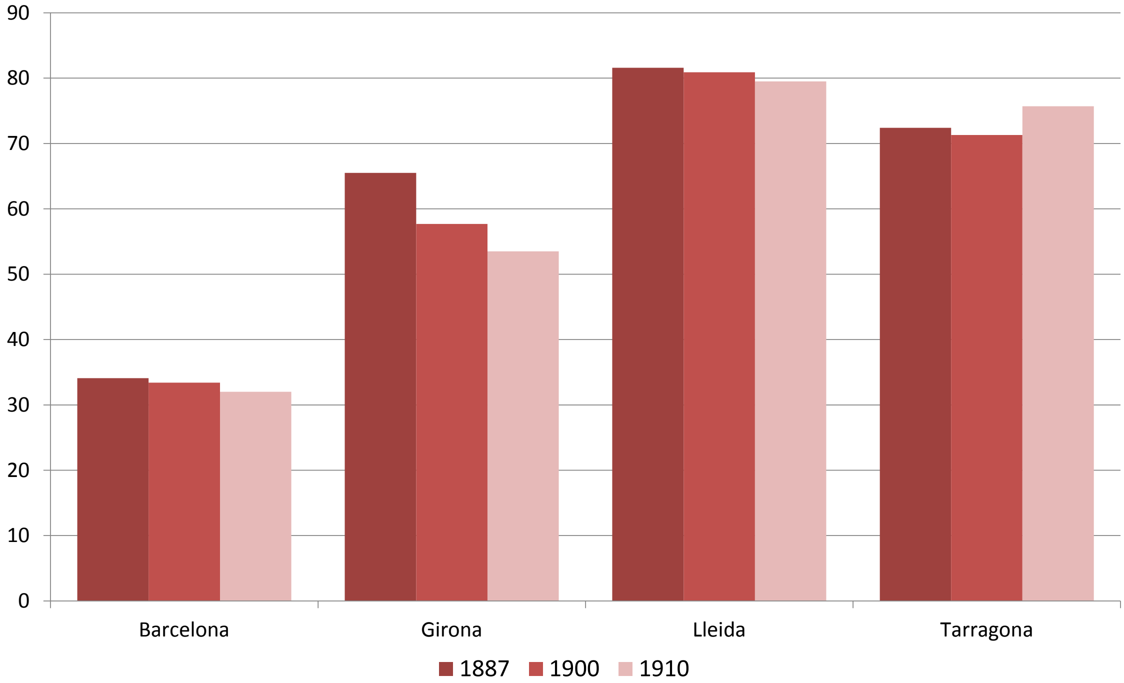
Second, after controlling for population density, the presence of a railway station, literacy rate and altitude, the differences between the heights of conscripts residing in municipalities with fewer than 5,001 inhabitants and those living in towns and cities (>5,000 inhabitants) drop substantially (Table 4, column 4). Nevertheless, rural residents remain significantly shorter, and so the existence of an urban premium for late-nineteenth century Catalonia is confirmed. Evidence suggests a height gap of around three quarters of a centimetre between young males living in rural areas (≤ 5,000 inhabitants) and those living in cities (> 20,000 inhabitants) (Table 4, columns 4 and 5). Although this difference might be regarded as slight, urban-rural height gaps of less than 1 centimetre are not uncommon in the context of nineteenth-century Europe when the relationship between height and population size is controlled for other factors.[10] In addition, though moderate, this rural-urban height gap is by no means irrelevant, particularly if we agree that height positively correlates with cognitive ability and is a good proxy for human capital, thus determining person's life opportunities and outcomes. A recent review of the modern evidence linking childhood stunting and undernutrition to economic outcomes concluded that a 1-cm increase in adult height was associated with a "4 per cent increase in wages for men and a 6 per cent increase in wages for women" (McGovern, Krishna, Aguayo & Subramanian 2017:17). Seen in this way, an urban premium of around three quarters of a centimetre might be considered less

[9] As a robustness check, and to control for potential multicollinearity between independent variables, we examined other specifications of the model. Thus, we dropped from the regression the variable municipal population density, which, as already argued, is highly correlated with municipal population size. In the same vein, we also substituted the population density variable with the variable municipal area, which, to some extent, might indirectly reflect the important issue of overcrowding. Table A2 in the Appendix presents the results we obtained after controlling for the variables railway station, literacy rate, altitude, and territorial dummies. Although coefficients may vary slightly, they confirm that the young males resident in rural municipalities were shorter than those living in cities of more than 20,000 people.

[10] See, for example, Humphries and Leuning (2009: 466-469), and Jaadla, Shaw-Taylor and Davenport (2020: 13) for England and Wales in the early nineteenth century, Cinnirella (2008: 340) for early and mid-nineteenth-century Britain, and Heyberger (Heyberger 2014: 128-130) for mid-nineteenth-century France. In all these cases, urban heights are lower.

negligible than it initially appears, particularly in terms of long-term inequality across individuals and territories.

Figure 8
Male population employed in the agricultural sector in Catalonia, 1887-1910
(in percentages)

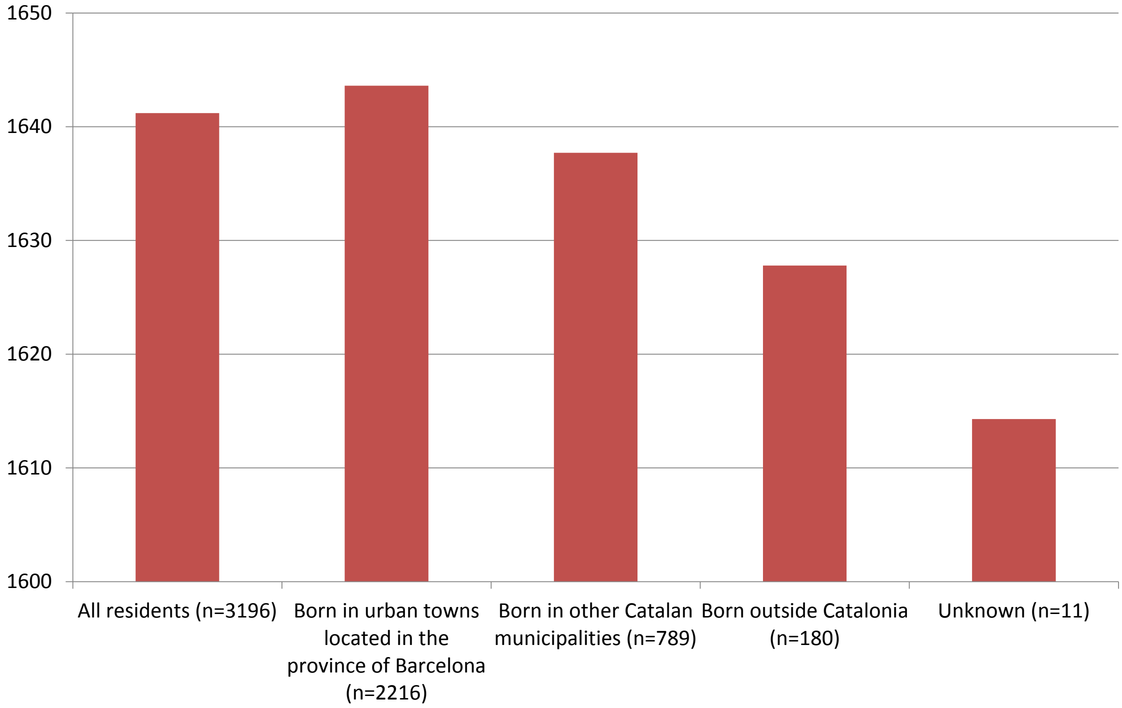


Notes and sources: Based on data from Nicolau (1990: 53).

What are the reasons for the urban premium in late nineteenth-century Catalonia? As suggested in previous sections, improvements in public health and food supply are the obvious candidates. In the context of this study, however, an additional factor has to be considered: migration. The dataset we use provides information on the place of residence of conscripts, but not on their place of birth. Therefore, it might be that the urban-rural height gap we observe in our data was mainly the result of rural boys and young males who, at a certain time point between their birth (1890) and the enlistment years (1911) left their place of birth to settle in other areas, particularly cities. This was not uncommon in nineteenth-century Catalonia (e.g. Camps 1995, Cabré 1999). Fostered by the labour opportunities (and probably the higher wages) provided by industrial growth, a notably high number of Catalans born in villages and small towns emigrated to the city of Barcelona and to other towns on its outskirts where industrial and service activities had become predominant (Figure 8). The same was true of the population born in the neighbouring regions of Aragón and València, who had also begun to settle in the province of Barcelona in the last decades of the nineteenth century (e.g. Silvestre 2004, Pinilla and Silvestre 2017, Pitarch Calero, Villar Garruta & López Gay 2018).

The question of whether or not migration influenced the late nineteenth-century Catalonia urban-rural height gap needs to be addressed. In order to do so, we have collected data for a sample of towns located in the province of Barcelona which had a population of more than 10,000 inhabitants in the census year of 1887. We call these localities "urban towns". Our dataset comprises the cohorts born in 1890, 1891 and 1892, who were enlisted in 1911, 1912 and 1913 respectively, and include about 3,200 observations (a number that we expect to expand in future work). We have classified the conscripts of these towns by place of birth.

Figure 9
The mean height of a sample of conscripts residing in the province of Barcelona in municipalities with more than 10,000 inhabitants by place of birth
(male cohorts born in 1890-92 and enlisted in 1911-13, in mm)



Notes and sources: Based on data from the *Actas de Clasificación y Declaración de Soldados* (Acts of Classification and Declaration of Soldiers), 1911-1913, and Ramon-Muñoz, R. and Ramon-Muñoz, J.M. (2021a).

Figure 9 summarises the raw results obtained. First, in the enlistment period of 1911-1913, conscripts born in urban towns were taller than others born elsewhere, who accounted for 30 per cent of the total observations. Perhaps as expected, residents born outside Catalonia were shorter than Catalan-born conscripts, whether or not they were born in the towns considered as urban. Second, as conscripts born elsewhere were shorter than Catalan-born conscripts, our calculations record a fall in the mean height of the residents in industrial towns in 1911-1913 (birth cohorts of 1890-1892) when those born outside Catalonia are included. While these data await a more formal analysis, these preliminary results suggest that our urban height data are to some extent a lower-bound representation of urban-born heights.

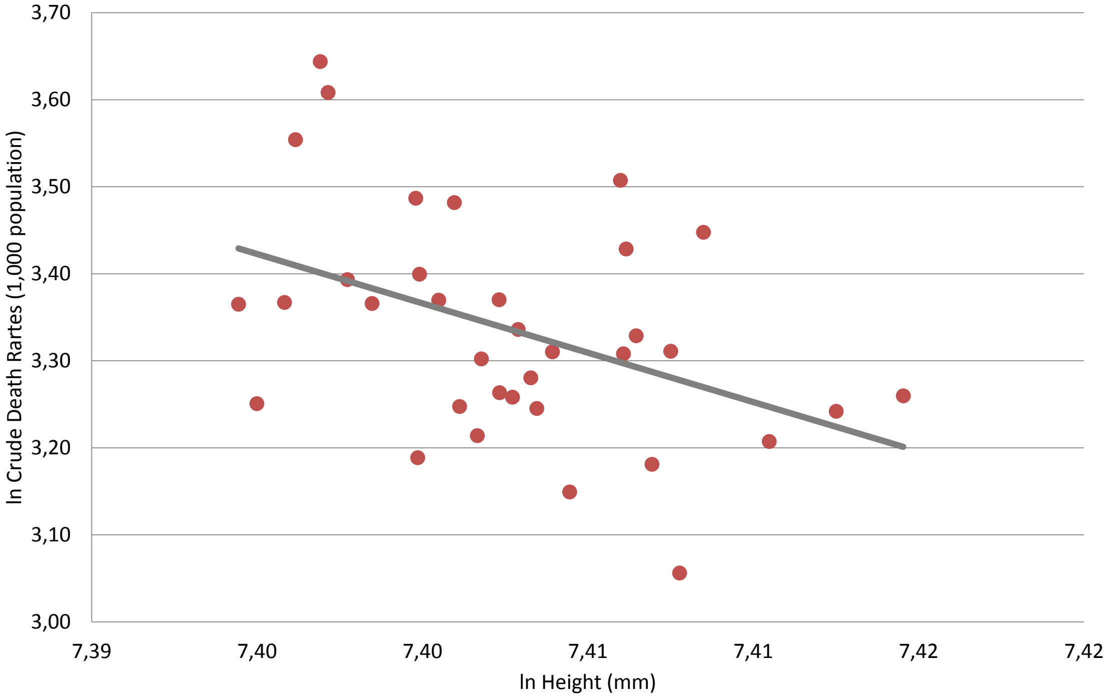
Unfortunately, at the present stage of research it is still difficult to fully assess whether the Catalan rural-born males living in urban cities in 1911 were taller (or shorter) than their rural-born and rural-resident counterparts. The literature available indicates a higher physical stature for rural-born movers compared to rural-born stayers (e. g. Humphries and Leunig 2009b, Juif and Quiroga 2019, and for international movements Kosack and Ward 2014, Blum and Rei 2018).

However, our sample data suggest otherwise: the mean height of those conscripts born in rural Catalan areas (in villages and towns of up to 5,000 inhabitants) residing in urban municipalities (in towns with more than 10,000 inhabitants) in 1911 was 1,640 mm. This figure is very similar to the 1,639 mm we obtain as the mean height of the rural draftees born in 1890 who were still living in rural areas in 1911, which, if confirmed by further analysis, would suggest that internal migration had only a modest impact on the urban premium we find in late nineteenth-century Catalonia. It might also suggest a higher urban premium than our data indicate.

Among other possible explanations of the urban premium observed, we have already mentioned the potential improvements in public sanitation and in housing conditions, as well as better and more widespread access to medical services in cities. In spite of these measures, however, contemporary descriptions do not always suggest very optimistic conclusions with regard to the extent of the progress achieved, above all for the city of Barcelona and the cohorts born before the early 1890s. Water supply and the sewerage system were still very deficient, which favoured the emergence and transmission of infectious diseases such as the 1885 cholera epidemic. Housing conditions do not appear to have been much better. Perhaps an exception to this grim picture is healthcare: indeed, the last two decades of the nineteenth century witnessed notable improvements in health services, mainly as a result of the opening of new hospitals, organisation of municipal medical services and, in general, an increase in local budget allocations. While the 1885 cholera epidemic accelerated the authorities' intervention in public health, it was only from the 1890s onwards that systematic action was taken to improve the water supply and sanitation (e. g. Capel and Tatjer 2008, Guàrdia, Rosselló and Garriga 2013, Sabaté 2017). In the years around 1890, mortality rates in the city of Barcelona were still higher than in the rest of the province. This pattern is also found in other Catalan and Spanish provinces (e.g. Ramiro-Fariñas and Sanz-Gimero 2000, Reher 2001, Escudero and Nicolau 2014, Pérez Moreda, Reher and Sanz-Gimeno 2015, Ramon-Muñoz, R. and Ramon-Muñoz, J.M. 2021b).

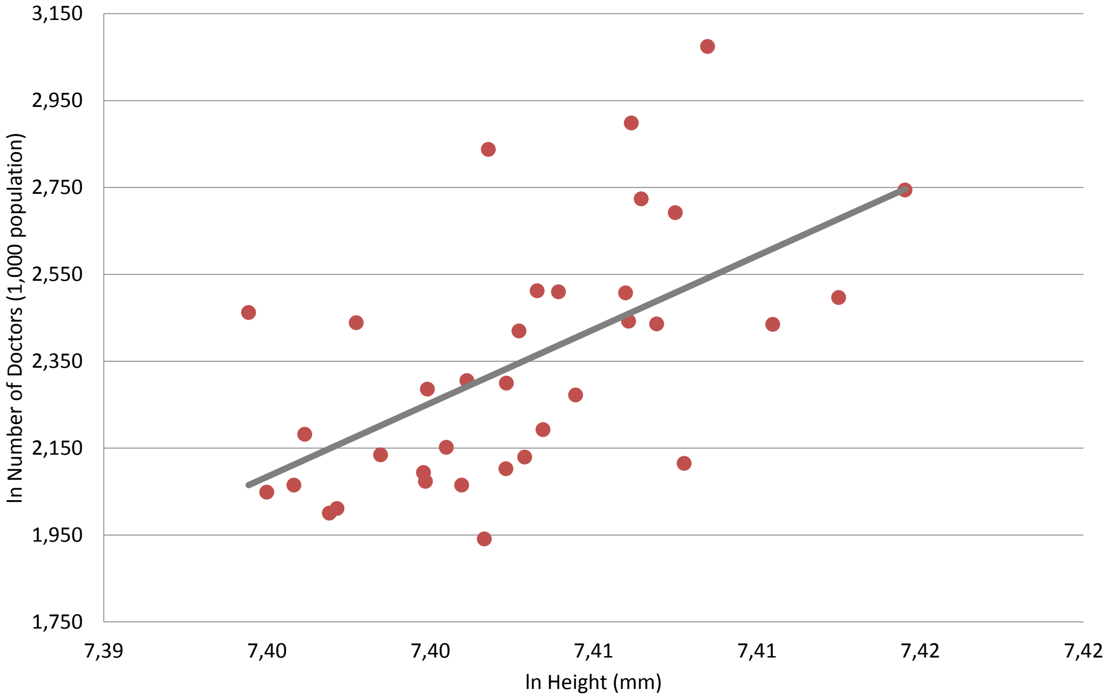
If the information above on mortality reflects environmental conditions and, therefore, improvements in public sanitation and healthcare, one might hypothesize that the urban height premium we find for the cohorts born in late nineteenth-century Catalonia had little to do with "care and cure" factors. If so, the Catalan case would differ from some recent well-researched cases in northern Europe (e.g. Heyberger 2014, Groote and Tassenaar 2020). Nevertheless, the data we have at our disposal, namely crude mortality rates and the number of doctors per 1,000 inhabitants at district (county) level (n=35), suggest that environmental factors may also have played a non-negligible role in explaining the Catalan urban-rural height gaps (Figures 10 and 11). Crude mortality rates correlate negatively with height, and this bivariate correlation is statistically significant (p-value=0.010). The number of doctors correlates positively with height at district level, and once again the correlation is significant (p-value: 0.001).

Figure 10
Relationship between mean height (mm) and crude death rates (per 1,000 population) in Catalonia by districts, c. 1890



Notes and sources: See text.

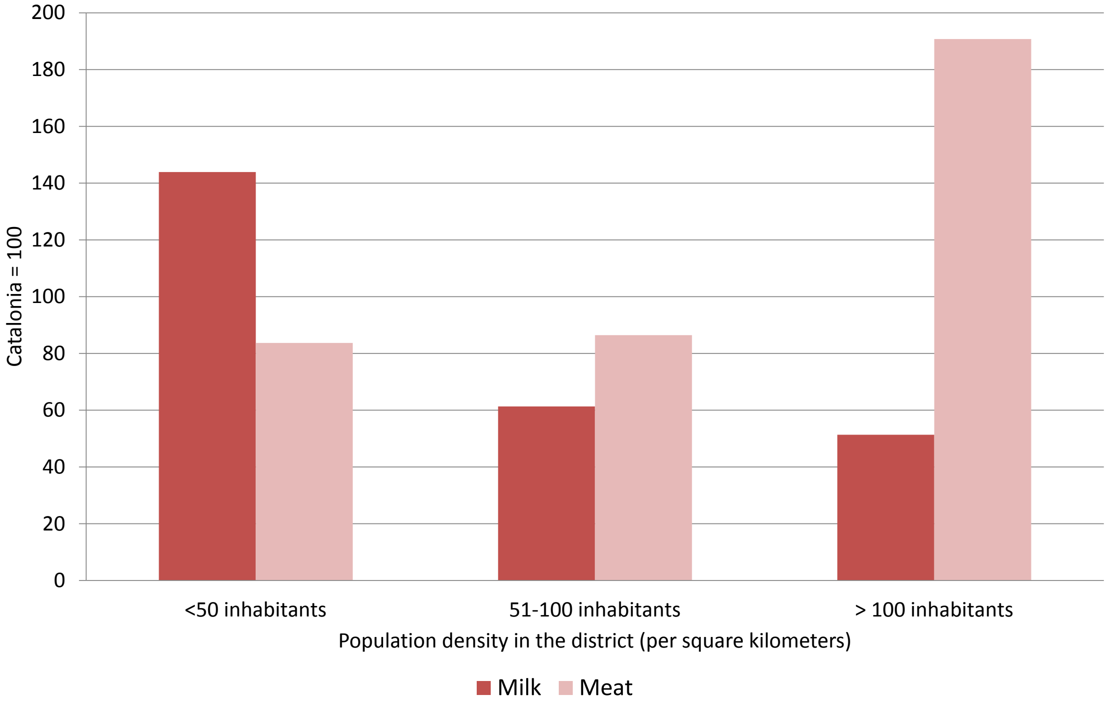
Figure 11
Relationship between mean height (mm) and the number of doctors (per 1,000 population) in Catalonia by districts, c. 1890



Notes and sources: See text.

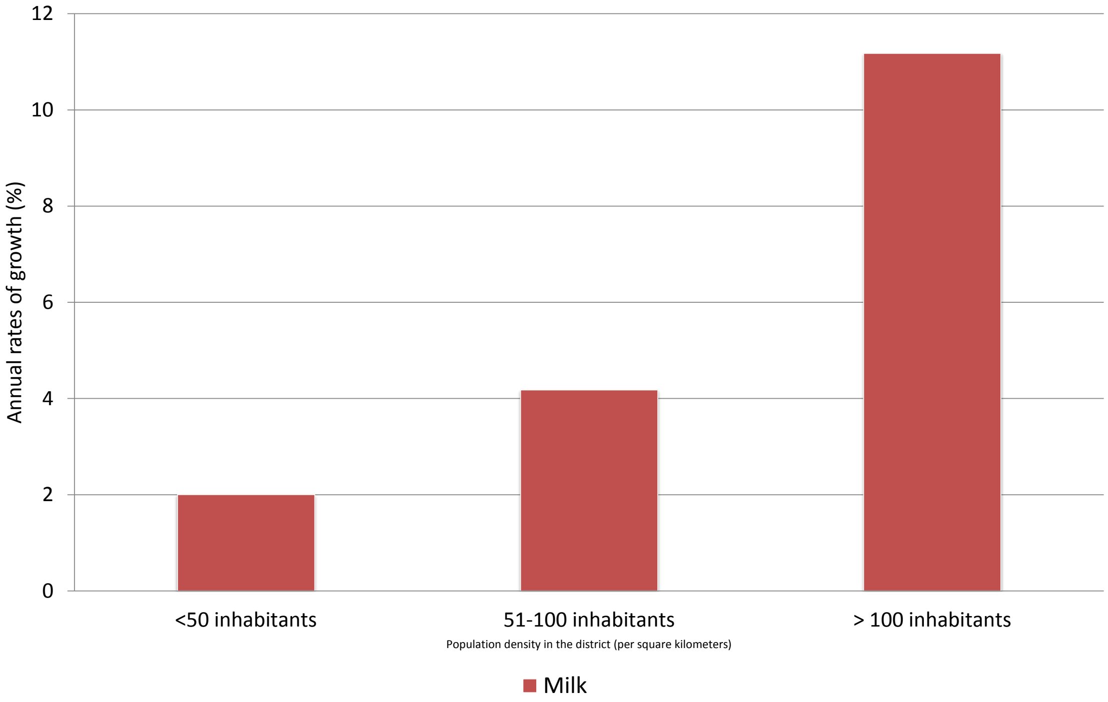
Another group of factors that might also explain the urban premium in late nineteenth-century Catalonia is to do with improvements in the quantity and quality of food availability for urban dwellers (e.g. see Steckel and Floud 1997b for an overview of the role of nutritional factors in explaining biological living standards). Table 4 shows that the overall influence of the railway on height is, in general, not statistically significant. The possibility that the results would have been different if we had used a different proxy for measuring the impact of railways on height cannot be ruled out (Heyberger 2014). In fact, the existing evidence suggests that food availability improved in the last decades of the nineteenth century, thanks above all to the greater intake of high-protein products (e.g. Cussó and Garrabou 2003-04: 73). Estimates in Barcelona, for example, show that per capita meat consumption increased by 44 per cent between 1881 and 1900; and perhaps more importantly, per capita milk consumption more than tripled between 1865 and 1900 (Nicolau and Pujol 2005: 117; Hernández Adell and Pujol 2017: 89). Milk is a high-protein product, whose intake has been, in general, positively associated with physical stature (e.g. Takahashi 1984, Baten 2009, De Beer 2012).

Figure 12
Estimates of per capita consumption of milk and meat according to population density in Catalan districts, c. 1890 (Catalonia=100)



Notes and sources: See text.

Figure 13
Estimates of the increase in per capita milk consumption of milk according to population density in the Catalan districts, 1865-1891
(annual rates of growth, %)



Notes and sources: See text.

This rapid increase in the availability of high-protein products deserves further comment. As expected, our preliminary estimates based on the available Spanish cattle censuses (Giralt 1990) show that, by the turn of the nineteenth century, per capita milk consumption (as proxied by milk availability) was still higher in the rural areas of northern Catalonia than in urban centres such as Barcelona (Figure 12), although it was in the districts with higher population density where per capita consumption had grown the most since the 1860s (Figure 13). In addition, the same estimates suggest that, as far as meat is concerned, per capita levels of consumption were lower in rural than in urban districts. These estimates are based on cattle slaughtered in slaughterhouses for public consumption, a measure which probably underestimates the consumption of meat products in rural areas. In spite of this, the higher levels of per capita meat consumption in cities do not seem surprising in the light of the available evidence for Spain (e.g. Pérez Moreda, Reher and Sanz-Gimeno 2015: 312).

5. Conclusions

This study has explored whether (and if so, to what extent) there was an urban-rural height gap in the north-eastern Iberian region of Catalonia in the nineteenth century. By using long-term data on heights, it first showed that as industrial production grew between the early 1840s and the late 1860s urban heights declined, and that urban dwellers remained on average shorter than that of their rural counterparts. These findings suggest both the existence of an "early industrial growth paradox" and the emergence of an "urban penalty" in the middle decades of the nineteenth century. From the late 1860s onwards, urban heights began an upward trend and in the last quarter of the nineteenth century the previous urban penalty turned into an urban premium. These preliminary findings qualify previous studies suggesting the absence of an urban penalty in the Iberian Peninsula. They also place Catalonia in the context of the European regions that experienced a transition from an urban penalty to an urban premium during the second half of the nineteenth century (e.g. Tassenaar 2019, Groote and Tassenaar 2020).

The urban height premium which emerged in Catalonia in the last quarter of the nineteenth century is further confirmed by the construction of a unique new dataset consisting of more than 16,000 observations for the cohort of males born in the year 1890 and enlisted in the year 1911 and covering 909 out of the 948 municipalities that form present-day Catalonia. The broad geographical coverage of our dataset represents a real novelty in the context of historical anthropometrics in Iberia.

By applying cross-sectional data and an ordinary least squares (OLS) model, the urban premium is confirmed after controlling for population density, presence of a rail station, literacy rate, and altitude. The results of our test show an urban premium of around three quarters of a centimetre for young males living in cities (> 20,000 inhabitants) compared to those residing in rural areas (≤ 5,000 inhabitants), which, thought moderate, is not unsubstantial if we place this height difference in a broader context. A linear relationship between physical stature and population size is, nevertheless, not observed when control variables are included in the regressions. Other studies using large samples have suggested a lack of a linear relationship between height and population size, and this also seems to be the case of Catalonia.

This paper has also explored the reasons why urban dwellers in late nineteenth-century Catalonia were taller than their rural counterparts. At present, we can only hypothesize that internal migration exerted a modest effect. Further analysis should confirm whether the urban height premium in late nineteenth-century Catalonia is better explained by the epidemiological environment or by nutritional factors, and, if so, to what extent.

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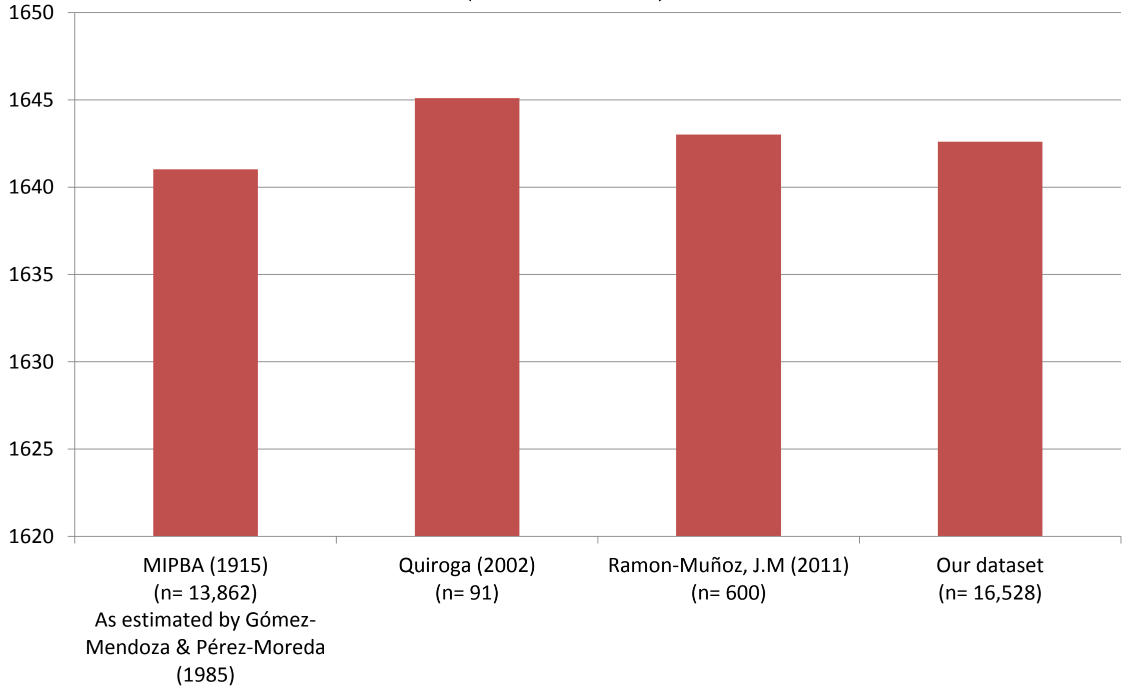
Appendix

Table A1
Number of conscripts with height data, 1840-1915

Period of Birth	**Period of Recruitment**	**Rural** No.	%	**Urban** No	%
1840-1844	1860-1864	262	28.6	655	71.4
1845-1849	1865-1869	364	23.1	1215	76.9
1850-1854	1870-1874	276	21.1	1028	78.9
1855-1859	1875-1879	491	27.3	1307	72.7
1860-1864	1880-1884	516	32.3	1080	67.7
1865-1869	1885-1888	580	20.1	2309	79.9
1870-1874	1889-1893	652	21.8	2336	78.2
1875-1879	1894-1898	698	22.6	2395	77.4
1880-1884	1899-1904	727	22.1	2560	77.9
1885-1889	1905-1910	731	22.8	2477	77.2
1890-1894	1911-1915	886	27.1	2389	72.9
1895-1899	1916-1920	758	23.7	2440	76.3
1900-1904	1921-1925	774	22.5	2661	77.5
1905-1909	1926-1930	812	24.1	2558	75.9
1910-1915	1910-1914	710	23.9	2263	76.1
Total		9,235	23.7	29,672	76.3

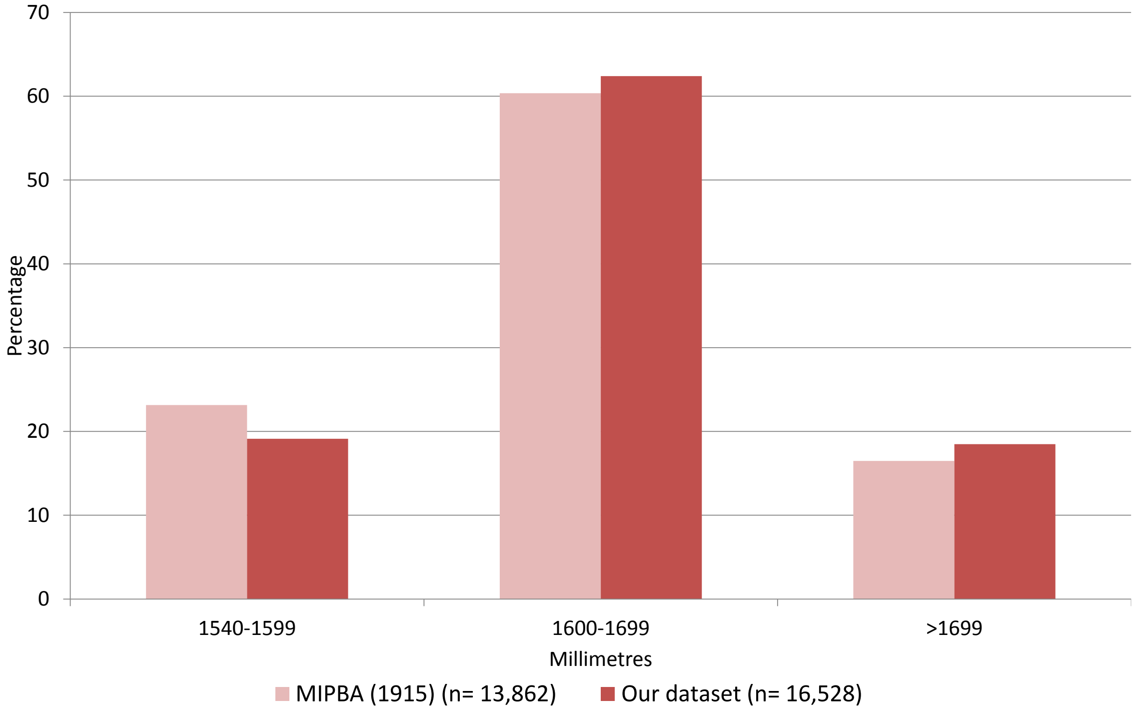
Notes and sources: Based on data from the *Actas de Clasificación y Declaración de Soldados*, 1863-1935 from four rural towns in western Catalonia, Balaguer, Cervera, Juneda and Tàrrega, and three urban industrial Catalan cities in central and southern Catalonia, Igualada, Manresa and Reus.

Figure A1
The mean height of the Catalan male cohorts born around 1890
(in millimetres)



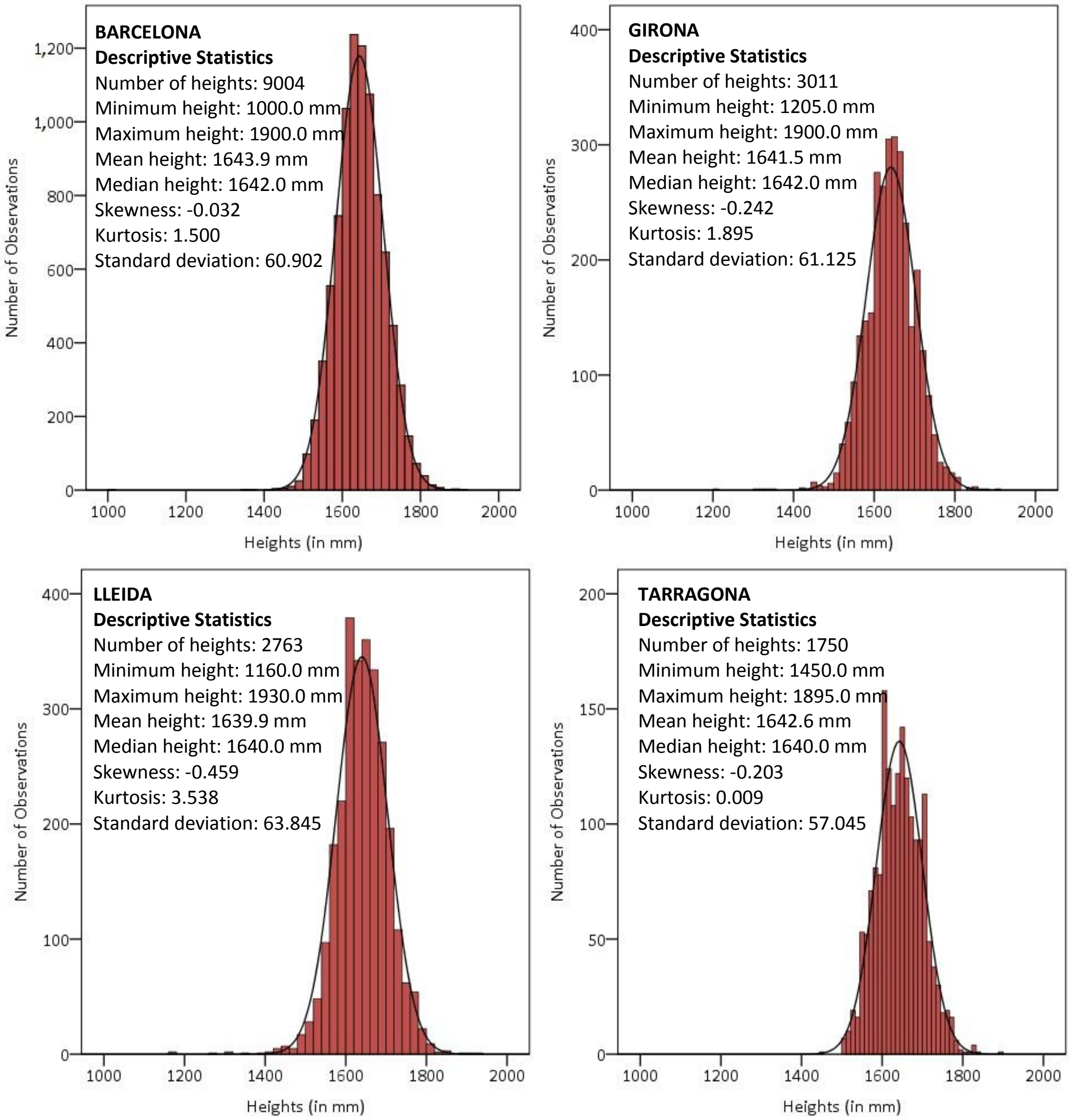
Notes and sources: MIPBA (1915) stands for *Estadísticas de Reclutamiento y Reemplazo del Ejército* (Ministerio de Instrucción Pública y Bellas Artes, 1915 and refers to the birth cohort of 1892. Quiroga's figure is the result of a three-year average for the birth cohort in the period 1889-1891. See also Table A1 and text.

Figure A2
The distribution of heights in our dataset (birth cohort of 1890) and in the *Estadísticas de Reclutamiento y Reemplazo* (birth cohort of 1892): conscripts based on Catalonia in the enlistment year with a height of 1,540 mm or more



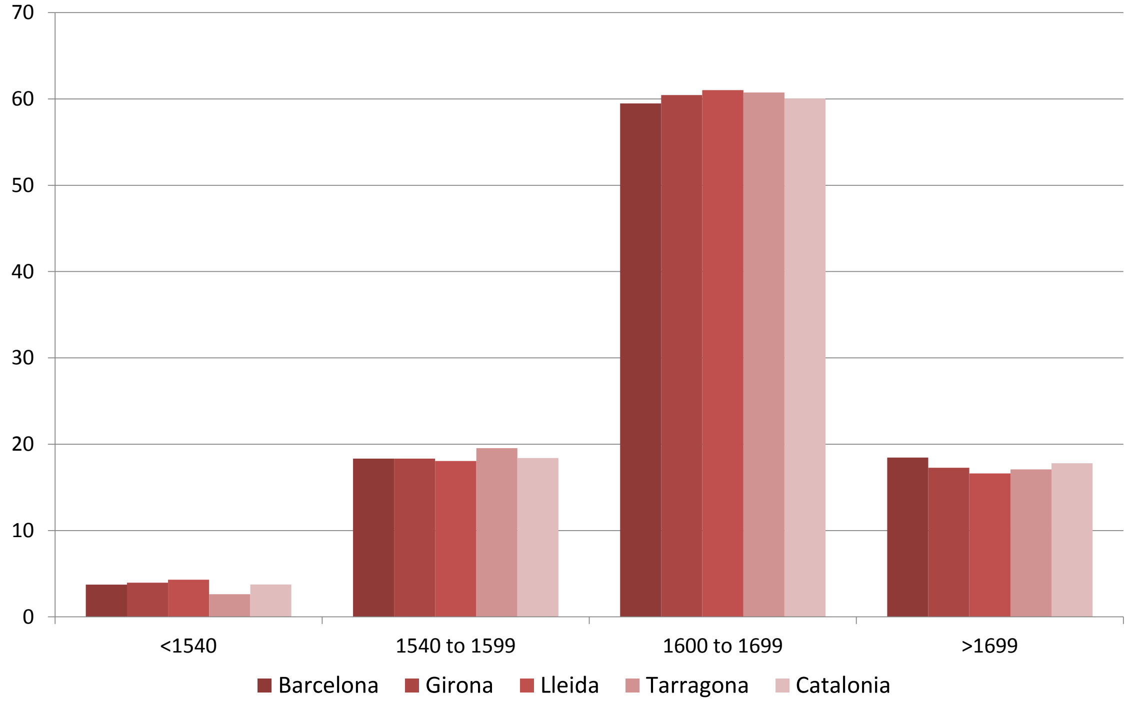
Notes and sources: 1,540 mm. was the minimum height established by law to serve in the army. See also text.

Figure A3
Distribution of heights of Catalan conscripts and descriptive statistics by provinces
(male cohort born in 1890 and enlisted in 1911)



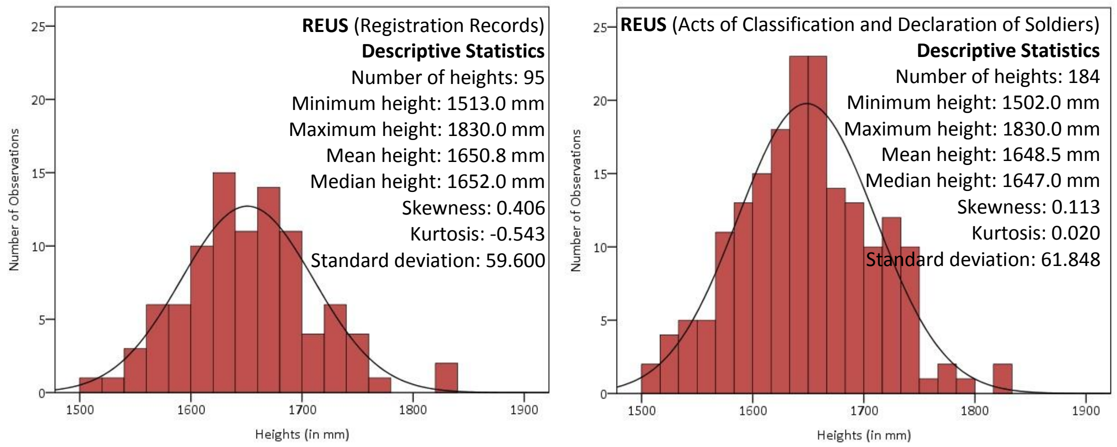
Notes and sources: See text.

Figure A4
Percentage of heights below and above the minimum height of 1,540 mm by provinces
(male cohort born in 1890 and enlisted in 1911)



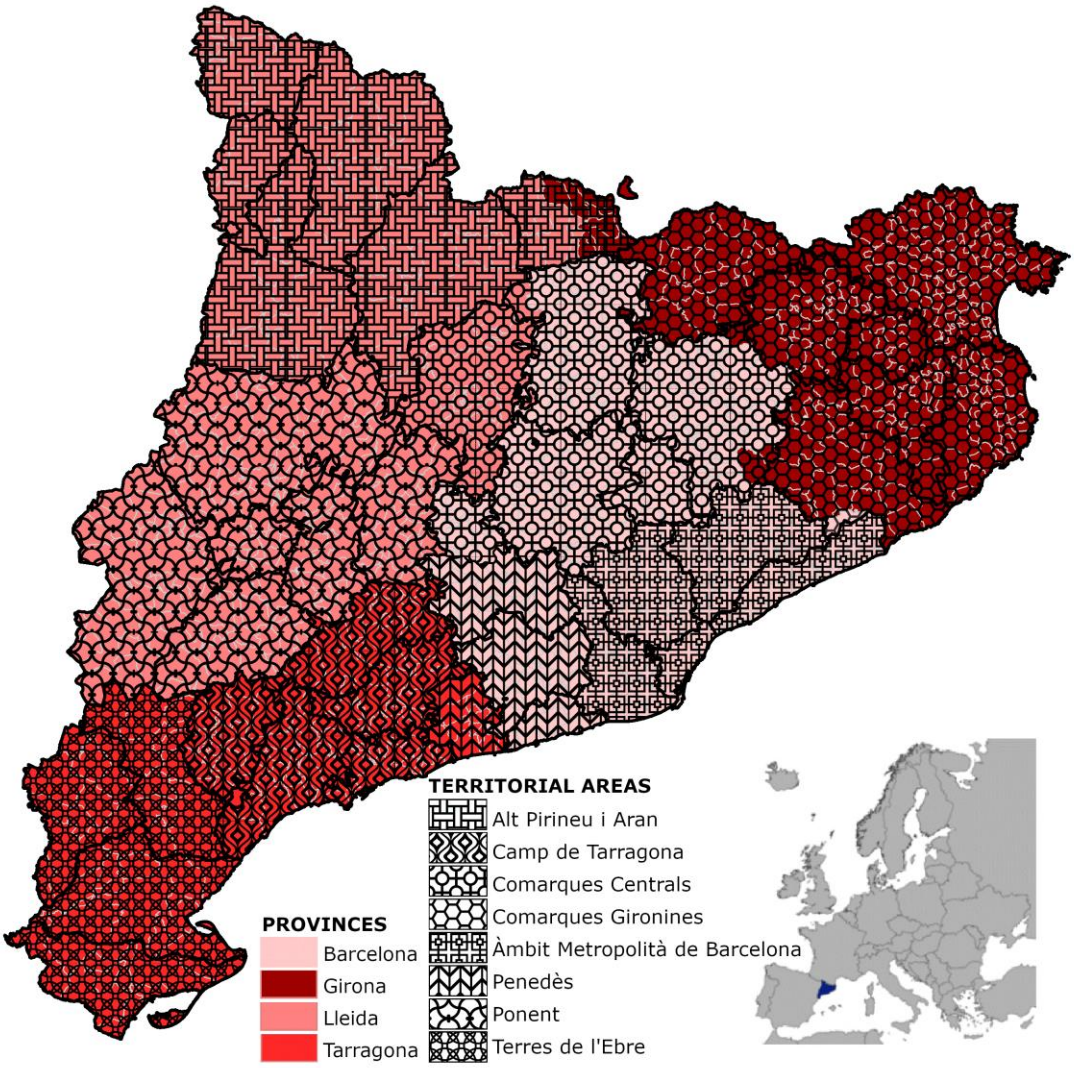
Notes and sources: See text.

Figure A5
Distribution of heights of the conscripts of Reus and descriptive statistics
(male cohort born in 1890 and enlisted in 1911)



Notes and sources: *Acta(s) de Clasificación y Declaración de Soldados* for Reus, 1911. See also text.

Figure A6
Map of Catalonia: provinces, counties and territorial areas



Notes and sources: Based on Eurostat (http://epp.eurostat.ec.europa.eu), Municat (http://municat.gencat.cat), and IDESCAT (https://www.idescat.cat/codis/?id=50&n=28).

Table A2
The impact of population size on male heights in Catalonia in the cohort born in 1890
(Dependent variable: Individual male height, mm)

Variables	(A)	(B)	(C)
Population Size:			
≤2,000 inhabitants	−6.190***	−4.595**	−6.625**
	(2.155)	(1.828)	(2.906)
2,001 - 5,000 inhabitants	−6.852***	−5.178***	−6.697***
	(2.161)	(1.728)	(2.531)
5,001 - 10,000 inhabitants	-5.100	−3.484	−4.947
	(3.590)	(3.367)	(3.747)
10,001 - 20,000 inhabitants	-4.324	−2.585	−3.951
	(3.590)	(3.035)	(2.979)
> 20,000 inhabitants	Ref.	Ref.	Ref.
Population density	−0.001		
	(0.001)		
Area			−0.018
			(0.020)
Railways station	−0.508	−0.391	−0.514
	(1.761)	(1.750)	(1.761)
Literacy rate	0.139	0.126	0.102
	(0.091)	(0.087)	(0.095)
Altitude	−0.017***	−0.017***	−0.017***
	(0.004)	(0.004)	(0.004)
Dummies at territorial level	Yes	Yes	Yes
Constant	1,646***	1,644***	1,647***
	(4.567)	(4.404)	(6.101)
R-squared	0.012	0.012	0.012
Observations	16.528	16,528	16,528

Sources and Notes: *** p<0.01, **p<0.05, *p<0.10. Clustered robust standard errors in brackets. For comparative purposes, column A includes the results already shown in Table 4, column 6.