ANTHROPOMETRIC HISTORY OF BRAZIL, 1850–1950: INSIGHTS FROM MILITARY AND PASSPORT RECORDS

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ABSTRACT

Trends in human welfare in Brazil have remained shrouded by a dearth of historical evidence. Although quantitative scholars have revealed the efficacy of the First Republic (1889–1930) in fomenting economic progress, the extent to which Brazil's early economic growth fostered improvements in health remains unclear. This paper fills this void in scholarship by relying on hitherto untapped archival sources with data on human stature—a reliable metric for health and nutritional status. My analysis centres heavily on a large ($n \approx 16{,}000$), geographically-comprehensive series compiled from military inscription files, supplemented by an ancillary dataset drawn from passport records ($n \approx 6{,}000$). I document inferior heights in the North and Northeast that predated the advent of industrialisation. At the national level, my findings reveal an increase in stature of over 2.5 cm between soldiers born in the 1880s and those born in the 1910s. In the South and Southeast, I argue that increased real income and public-health interventions explain the earlier upward trend in heights, while rural sanitary reforms were most important in the North and Northeast, where heights remained stagnant until the 1910 decade and diseases such as hookworm and malaria were most rampant.

Keywords: economic history, Brazil, anthropometrics, heights, population health

JEL Code: N0, N3, I3, I18

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RESUMEN

Las tendencias en el bienestar humano en Brasil no han sido estudiadas por una escasez de evidencia histórica. Los estudios cuantitativos muestran la eficacia de la Primera República (1889–1930) para fomentar el progreso económico, pero no queda claro hasta qué punto el crecimiento económico inicial de Brasil generó mejoras en la salud. Este trabajo llena este vacío en la literatura al basarse en fuentes primarias hasta ahora no estudiadas, con datos sobre la estatura humana, una métrica confiable para la salud y el estado nutricional. Mi análisis se centra en una gran serie ($n \approx 16{,}000$), geográficamente integral, compilada a partir de archivos de inscripción militares, complementada por un conjunto de datos auxiliares extraídos de registros de pasaportes ($n \approx 6{,}000$). Se documentan estaturas inferiores en el norte y el noreste que precedieron el advenimiento de la industrialisación. Al nivel nacional, mis hallazgos revelan un aumento en la estatura de más de 2,5 cm entre los soldados nacidos en la década de 1880 y los nacidos en la década de 1910. En el sur y el sureste, el aumento de ingresos reales y las intervenciones de salud pública explican la tendencia alcista en las estaturas, mientras que las reformas sanitarias rurales fueron más importantes en el norte y el noreste, donde las estaturas permanecieron estancadas hasta la década de 1910 y las enfermedades como la anquilostomiasis y la malaria eran más generalisadas.

Palabras claves: historia económica, Brasil, antropometría, alturas, salud poblacional

1. INTRODUCTION

Relying on human height data drawn from archival military and passport records, this paper is the first long-run, quantitative study on trends in human development across Brazilian regions from 1850 to 1950. During this period, Brazil underwent profound political, social and economic transformations, yet we know little about how such transformations shaped human health due to a lack of historical evidence. Scholars generally agree that living conditions remained low and stagnant during the Imperial period (1822–1889), but the evolution of living standards during First Republic (1889–1930) has remained particularly elusive. According to many scholars, policy formation during this period remained captive to landed interests and did little to improve the life of the average Brazilian. The extant literature on health in Brazil during this time period has been inhibited from adequately assessing the public-health outcomes of institutional developments due to severe data constraints (Adamo

1986; Benchimol 1999; Otovo 2009). Scholars debate when modern economic growth began in Brazil, with some attributing more weight to the First Republic and others pointing to the import-substitution industrialisation (ISI) policies pursued during the Vargas period (1930–55). Data on income prior to 1940 are scarce, making it difficult to know how the broad economic shifts between the Empire, First Republic and the Vargas periods impacted the health of Brazilian population. This paper examines the association between economic growth and human wellbeing by comparing height trends across these major social and economic watersheds. Elaborating a heights series for the country is of the utmost importance to understand its demographic transition.

The objective of this paper is to estimate historical health trends in Brazil from 1850 to 1950 with the use of data on human height drawn from Brazilian military and passport records. A second objective is to trace the evolution of living standards across Brazil's regions in order to shed light on the emergence of the country's regional health gap. As a measure of net nutritional status, heights capture the interaction between nutritional intake and the demands made on those nutrients by homeostasis, defence of infections and work expenditure. Thus, adult heights measure the outcome of early-life conditions and shed light on early-age health (Steckel 1998). Data on traditional health indicators, such as life expectancy or infant mortality, are inaccurate, fragmentary in interval or limited with respect to locality until roughly 1940. Further, the existing anthropometric studies that cover the 19th and early-20th centuries rely on localised sources such as prison records, thus tending to observe individuals from distant regions as migrants and to obfuscate regional height patterns (Frank 2006; Baten *et al*. 2009). Other anthropometric research within the period studied here has utilised worker registration cards from the southern state of Rio Grande do Sul (Monasterio and Signorini 2008), a source that inadequately captures individuals employed in the informal and agricultural sectors. Both sources, prison records and state-specific worker registration cards, fail to effectively capture trends in health at the national level. I argue that military records offer the most accurate vision of height trends for the interval in question. The evidence on heights illustrates that the state impetus to modernise Brazil in the late-19th and early-20th centuries had a positive impact on health, but improvements in health occurred unevenly across Brazilian regions. I argue that real-income growth and the earlier investments in public-health institutions in the southern coffee sector explain the time trends and regional patterns in height.

This paper proceeds as follows: Section 2 provides a brief historical background. Section 3 discusses methodology and summarises the sociodemographic characteristics of the datasets. Section 4 presents regression results while also detailing heterogeneity in the trends of subgroups, first

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for the military and then for the passports samples. Section 5 compares the height estimates from the military and passports samples to other historical height estimates for Brazil. Section 6 discusses the results and proffers potential explanations for the temporal trends and regional patterns in height. Section 7 concludes.

2. HISTORICAL OVERVIEW

How did the health of the Brazilian population change as the country industrialised and began its period of modern economic growth? More specifically, how did living conditions evolve during the agro-export phase (roughly 1870–1930) and ISI period (after 1930)? Over the 1850–1950 interval, Brazil transitioned from a pre-industrial society based predominantly on sugar exports to an industrialising economy buttressed by its comparative advantage in coffee exports. The Imperial period in Brazil (1822–1889) was predominantly marked by economic stagnation, as high transportation costs and informational asymmetries hemmed down aggregate growth (Leff 1982; Baer 2014). The institution of slavery and the slow pace of economic growth provided little opportunities for upward mobility (Costa 1985).

Concentrated in the Southeast, the coffee sector became Brazil's largest source of income over the course of the 19th century, and with the emergence of a burgeoning export sector, modern industrial development followed circa 1870 (Dean 1970; Cano 1977). Around this same time, Brazil embarked on a path of gradual emancipation, culminating with abolition in 1888. As the agricultural elite became concerned with the possibility of labour shortages prior to emancipation in 1888, state officials developed policies to promote European immigration to Brazil (Holloway 1980). In last quarter of the 19th century, emancipation, industrialisation and immigration assured a steady wave of migrants to Rio de Janeiro and other cities in the South and Southeast. Since the wave of international migration has the potential to impact the height estimates, it will be important to distinguish any potential positive effects on stature emanating from the immigrant population from that of the Brazilian-born (see Section 4 below).

Democratic governance came to Brazil in 1889 with the emergence of the First Republic (1889–1930). Recent research in economic history on this period has pointed to the improvements in institutional development and the provision of public goods that fomented economic growth (Triner 2000; Hanley 2005). Republicanism allowed for the states to collect taxes on their exports, thus fuelling public investment in key areas of human capital formation like primary education (Musacchio *et al*. 2014). Gains in transportation were also significant; facilitated by government subsidies, railroad construction intensified in the 1890s and augmented both agricultural and industrial productivity (Summerhill 2003). Public spending

increases in hard infrastructure and education have received considerable attention from quantitative historians, yet gaps in our knowledge remain regarding the health implications of policy changes during the Republican era. This paper helps to mend this gap by discussing the impact of these measures on heights.

In addition to an increased degree of economic interventionism, policies during the First Republic also amplified state activism in public health and sanitation (Hochman 1995). Marking a disjuncture with the *ad hoc* methods disease control that prevailed during the Empire, the 1889 bill on public health and sanitation centralised and modified sanitation codes and medical care (Meade 1997). The government executed urban and rural hygiene reforms in the 1900s and 1910s, focusing first on sanitation and clean-water technologies in urban areas and then on rural sanitation, respectively. As we shall see, the decade of the 1910s marked the beginning of state involvement in regulating sewage disposal in rural areas, and soldiers born in this decade reveal a marked height advantage over their older predecessors.

Changes ushered in by WWI meant that imports of industrial machinery to Brazil virtually ceased with the onset of the war. At the same time, the domestic price level in Brazil began to rise, and inflation remained high (and highly volatile) for much of the rest of the century. Historians have documented a drastic erosion of purchasing power of the labouring classes as a result of the inflationary spiral in the mid-1910s (Ball 2013).

The Vargas era (1930–1955) is known by many as the genesis of modern economic growth in Brazil. The effects of the Great Depression provided the stimulus to diversify the Brazilian economy, giving rise to the era of ISI. The effect of these policies was rapid economic growth; from 1930 to 1945, GDP per capita rose by an average of 4 per cent per annum (Vidal Luna and Klein 2014, p. 106). Scholars continue to debate when Brazil's modern economic growth began, and many dependency-minded historians view the Vargas period as the genesis of economic growth and general wellbeing. Understanding how heights evolved during the First Republic can greatly inform this debate.

3. DATA AND METHODS

Common sources employed in the study of living standards—data on income, life expectancy and infant mortality—are insufficient to study health trends in Brazil in the 1850–1950 period. Heights provide the most suitable alternative to empirically study Brazilian health trends in a long-run perspective. Since their first use by economic historians in the late 1970s, height data have provided a window into the health and welfare of difficult-to-reach populations. Stature can best be conceptualised as

nutritional status—one's cumulative nutritional intake, minus the claims made on those nutrients by physical exertion and the defence of disease. The crucial periods influencing terminal adult height are the intrauterine, infant (before age 3) and adolescent stages of human growth. If nutritional status is insufficient during these times, the human body responds by limiting its physical growth. Heights are particularly sensitive to chronic rather than acute infections, especially those of the oral–faecal mode of transmission to which infants and toddlers are highly susceptible (Floud *et al*. 2011). The World Health Organization lists diarrhoeal diseases, malaria and intestinal parasites as the leading causes of chronic malnutrition and stunting in the developing world today (Stewart *et al*. 2013).

Contemporary anthropometric research has documented a correlation between height and income, but scholars debate the channels of causation (Floud *et al*. 2011). Despite this general correlation, heights and income do not always move in tandem. One striking example of this can be found in the height trends of early-industrialising economies. For example, in the decades preceding the U.S. Civil War, the literature has documented a precipitous decline in stature in spite of the period's sustained economic growth—a conundrum referred to as the «antebellum puzzle» (Komlos 1998). Many researchers point to a more virulent disease environment brought on by urbanisation and market integration as the cause of the decline in heights (Cuff 2005; Yoo 2012).

In other cases, industrialisation and market integration did not provoke such a decline in stature. For example, in contrast to the patterns observed in many European countries and North America, data on Spain show that urban soldiers held a height advantage over rural soldiers between 1870 and 1930 (Martínez-Carrión and Moreno-Lázaro 2007). In Sweden, industrial expansion after 1870 was accompanied by improvements in hygiene and childcare, and heights increased as a consequence (Sandberg and Steckel 1997). In order to analyse the health implications of industrialisation, Steckel (1998) urges researchers to consider the timing of industrial growth relative to the expansion of the germ theory of disease. In the case of Brazil, as occurred in other late-industrialising nations such as Sweden and Spain, industrialisation and the implementation of public health measures informed by bacteriology occurred roughly at the same time in the final three decades of the 19th century.

3.1 Data Description

This study relies on two sources for anthropometric data: soldiers of the Brazilian army and passport-bearers travelling from the port of Rio de Janeiro. The main dataset consists of a random sample of 16,341 observations from army induction files located at the AHEX (*Arquivo Histórico do*

Exército, or Historical Military Archive) divided into decadal birth cohorts ranging from 1850 to 1950. A random sample of 6,025 observations of passports collected from the AN (*Arquivo Nacional*, or National Archive) serves as an ancillary dataset and is divided into quinquennial birth cohorts ranging from 1870 to 1910. Since the military sample tends to capture individuals from the lower socio-economic statuses, the sample of passports allows for an examination of height trends amongst the higher echelons of Brazilian society that would otherwise not be possible with soldier heights alone. Below, I give a brief overview and present the socio-demographic traits of the datasets.

3.2 Military Data

Although some inhomogeneities in record keeping existed over time, the military recruitment files generally included the name of the soldier, the names of his parents (if known), his place and date of birth, skin colour, height, occupation prior to entering the army, literacy status, vaccination history, mode of entry and marital status. Although the AHEX contains no documentation that discusses how exactly the recruits were measured (i.e. if the recruits were barefoot, or if they were consistently measured with a right-angled instrument while standing against a wall), I assume that measurement error was generally low. Evidence to support the validity of the soldiers' height measurements can be found in the sample's distribution of heights. According to Komlos (2004), one convenient feature of height samples is that they generally follow a standard normal distribution. As seen in Figure 1, the distributions of heights from the military sample appear to follow normal distribution[1]. The histograms are separated by recruitment «regime». Regime 1 denotes soldiers inducted before 1916; Regime 2 indicates those incorporated between 1916 and 1936 when the minimum height requirement was 154 cm; and Regime 3 represents soldiers that entered the army after 1936 when the minimum height requirement was raised to 155 cm. Prior to proceeding with regression analyses, I examined the distribution of heights for the presence of univariate outliers, and I removed extreme univariate outliers from the

[1] Shapiro–Francia tests fail to detect a normal distribution at the 10 per cent level of significance (although the *P*-values are not far off for most cohorts). The large number of observations in each cohort, the minimum height requirement (for soldiers inducted after 1916) and the presence of some rounding/heaping are likely causes. Heaping is detectable in the military height series. In the absence of any digit preference, we would expect to see all of the last digits (0–9) account for 10 per cent of the total frequencies. In the total sample, measurements ending in 0 account for 15.41 per cent, while those ending in 1 account for only 7.77 per cent. Broadly, although there is some evidence to indicate that the height measurements suffered from some heaping, digit preference is not extreme throughout the study period.

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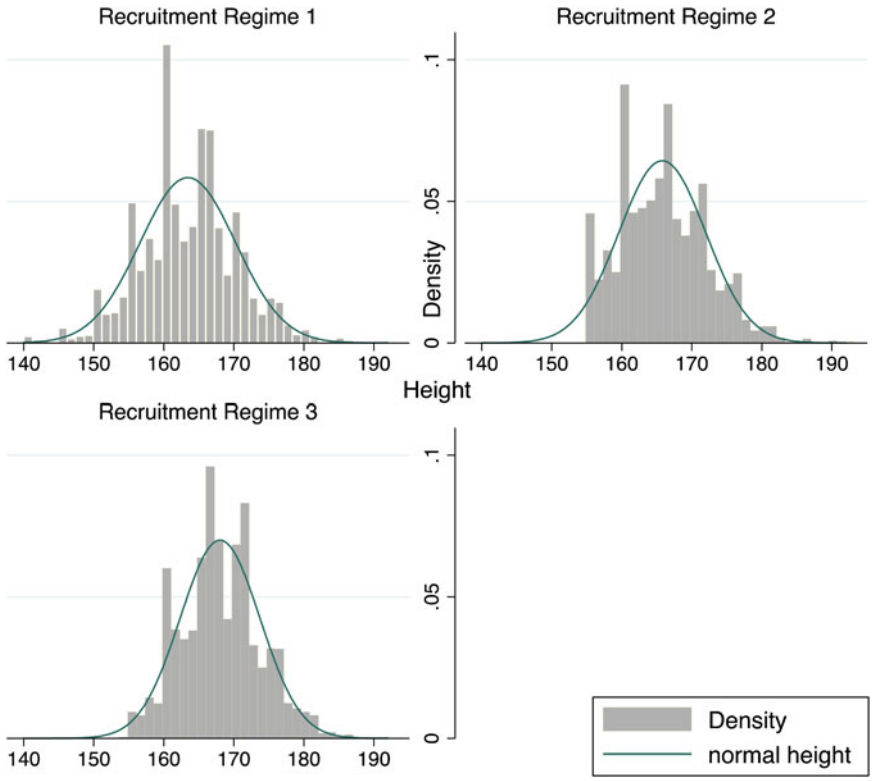
FIGURE 1
HISTOGRAM OF HEIGHTS, AHEX SAMPLE.



Source: Anthropometric data, see text.

sample (i.e. those cases lying outside the interval defined by 3× the interquartile range of height).

Table 1 presents the socio-demographic characteristic of the military series by decade of birth. I collapsed the reported skin colour descriptors into four categories to match census classifications[2]. The shifts in occupational

[2] Before cleaning the data, I logged over twenty descriptors for skin colour, ranging from *trigueira* (wheat coloured), to *cabocla* (indigenous), to *preta* (black) or *fula* (bronze-coloured), with a vast spectrum of mixed-race gradations (*parda clara* or light brown, *mulata*, *morena escura* or dark brown, etc.). In order to facilitate regression analysis, I collapsed the racial categories into four to match census classifications: white (branca), Amerindian (cabocla), mixed race (parda) and black (preta).

Regressions examining dark- and light-skinned soldiers separately display relatively little difference in height, except for the period associated with the greatest increase in stature from roughly

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TABLE 1
MILITARY SAMPLE STATISTICS

All figures are numbers of cases by 10-year cohort of birth											
Birth cohort	1850	1860	1870	1880	1890	1900	1910	1920	1930	1940	1950
Total cases	433	1,002	1,092	2,117	2,389	1,933	1,609	2,725	1,044	663	1,334
Skin colour											
Black	79	176	180	300	212	163	66	175	123	41	31
Mixed	218	504	595	1,107	1,358	975	506	1,048	491	376	835
White	113	297	310	632	689	775	1,048	1,502	445	246	465
Amerindian	21	37	42	109	80	12	2	0	0	0	0
Occupational category											
No occupation	399	948	960	1,897	1,421	331	96	265	218	328	658
Farmer	0	1	2	7	406	771	458	578	147	8	75
Domestic_serv	2	4	9	5	1	7	17	29	32	12	17
Transport	2	2	4	10	41	64	86	167	43	23	80
Commerce	5	13	15	52	136	256	264	419	111	63	70
Manufacture	60	85	140	208	248	329	440	749	280	110	140
Govt. and liberal professions	19	28	57	93	236	156	250	523	237	123	287
Region											
North	11	4	22	50	551	64	14	66	11	11	10
Northeast	319	644	660	1,340	1,312	766	237	399	165	139	298
Centerwest	13	56	76	47	5	31	62	44	45	152	433
Southeast	83	192	212	237	206	636	622	1,766	801	359	573
South	35	135	164	480	333	331	631	464	19	4	17

Source: Anthropometric data, see text.

composition are readily evident[3]. Although one would more adequately utilise the parents' occupation, López-Alonso (2012) points out that those parents that provided skills for their children also likely provided better nutrition and health, making soldiers' occupations valid for studying the impact of familial socio-economic status on heights. Unskilled occupations constituted most of the military sample until the birth cohort of 1880 when the unskilled share begins to decline. In the cohort of 1910 skilled-manual occupations become most prominent. The increase in the skill composition of the military sample likely reflects the underlying process of industrialisation and modernisation that took place over the study period.

Table 1 also exhibits a shift in the regional composition of the AHEX sample over the interval of study. I have grouped the soldiers by the five main geographic regions of Brazil—the North, Northeast, Centerwest, Southeast and South. Soldiers hailing from the Northeast far outnumbered any other region until 1910, when soldiers from the Southeast became most common. Soldiers hailing from the Northeast far outnumbered any other region until 1910, when soldiers from the Southeast became most common. For the majority of the 19th century, the Northeast accounted for roughly two-thirds of the total sample, while the South and Southeast represented between 10 and 20 per cent. These trends in the regional composition of the military sample largely correspond to regional population trends indicated by the censuses of Brazil. Although the regional distribution of the anthropometric sample deviates slightly with demographic trends of the total Brazilian population, I use weights derived from census data (both for regions and occupational groups) to render my regressions more reflective of the national population.

3.3 Passport Records

The AN holds two series of passport records from the Rio de Janeiro Civil Police—the authority responsible for maritime travel from the port of Rio de Janeiro—pertaining to individuals travelling from Rio between roughly

1880 to 1910, when soldiers with light skin display a small height advantage (of about 2 cm). There are reasons to believe that the near equivalence in height between light- and dark-skinned soldiers is a product of health screening applied universally to all incoming soldiers. Further, it is possible that the relative equality of height between the light- and dark-skinned soldiers reflects high young-age mortality selected on height. If infant mortality rates were higher amongst the populations of African descent, then those that survived to be incorporated in the military as young adults were most likely the most robust (and hence, taller). Although infant mortality data disaggregated by race/ethnicity are lacking for Brazil as a whole, in 1890 in Rio de Janeiro the infant mortality rate per thousand births amongst white individuals was 397.2, amongst blacks 496.6, and for the mixed-race Brazilians, 407.3 amongst mixed-race individuals. See Adamo (1986).

[3] I classified soldiers' and passport bearers' occupational categories to match the census classifications for the time period in question.

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1915 and 1935. Passport records indicate the date of issuance, date of birth, place of birth, place of residence, destination of travel, occupation and the physical characteristics (height, eye colour, hair colour and skin colour) of the applicant[4]. For passports issued between 1915 and 1919 and after 1934, the reporting of height was less consistent. For some years in the sample, principally the early 1920s, every individual boarding a ship was measured. In other years, it appears that all men were measured, while women and children were not. In most cases, women were not measured but assigned a categorical description of height, such as «tall», «short» or «normal». Due to the limited number of cases for female passport bearers, I do not include the female heights in this sample. See Table 2 for a breakdown of observations by 5-year birth cohort and sex.

Similar to the military files, there is little information about how, when and where the passport bearers were measured. In their majority, it appears that the police officer issuing the passport either physically measured the applicant or used the height measurement found on his or her supporting documentation[5]. However, the passport records may contain some self-reported heights, increasing the possibility of measurement error from rounding and leading to heaping (i.e. the rounding up or down of height measurements at diverse intervals). The distinct method of reporting heights in the passport series becomes clear when we examine the sample's distribution in graphical representation in Figure 2.

We can observe evidence of heaping since height values appear to be clustered around particular values. Measurements ending in 0s or 5s appear more abundantly than we would expect from a standard normal distribution. The presence of heaping may suggest that height values were not always measured by the scrivener but were at times self-reported. The evidence of height heaping complicates the interpretation of the passports sample to a degree, but it does not invalidate the claims we can make about the general trends. Methodologists affirm that rounding bias in anthropometric samples is self-neutralising; in conducting simulations, Steckel (1994) notes that the adverse aspects of heaping are self-cancelling and hence have a relatively minor bearing on sample means. That is, roughly the same amount of individuals tend to round their heights up relative to those that round their heights down. As a result, the bias from rounding tends to be neutral.

Viewed in comparison with the military sample, the sample of passports captures the more prosperous members of Brazilian society.

[4] Perhaps revealing some racial prejudice, most of the passport records did not include a description of skin colour, but rather a check mark. Cassia Roth (2016) reveals such a practice was prevalent in police cases in Rio de Janeiro in the early-20th century.

[5] Most passports noted a driver's license or ID card used as a supporting document for the issuance of the passport.

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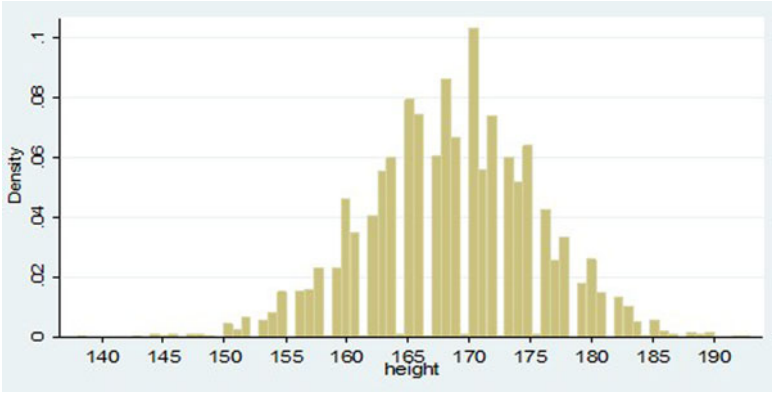
FIGURE 2
DISTRIBUTION OF HEIGHTS: PASSPORTS SAMPLE. HISTOGRAM OF HEIGHT VALUES.



Source: Anthropometric data (see text).

Table 2 charts the number of cases by occupational category and region of provenance for Brazilian-born men.

In contrast to the abundance of unskilled soldiers prior to 1910, the passports pertain largely to skilled-manual, white-collar and elite Brazilians. As we can see, travellers with skilled-manual professions accounted for the bulk of the sample, accounting for roughly 50 per cent across all cohorts. For those born between 1870 and 1895, the elite and white-collar travellers represented 19 and 15 per cent of the sample, respectively. From the interval from 1895 to 1910, elite travellers accounted for only 15 per cent of the sample, while white-collar individuals pertained to 20 per cent. Despite the minor fluctuation in the elite and white-collar share of the passports sample, unskilled labourers represented between 11 and 13 per cent across all birth cohorts. Within the unskilled occupational group, we can reasonably deduce that the passport bearers were somewhat wealthier than those from the military since they had the disposable income to purchase a ticket for travel.

The geographical limitations of a heights series culled from a local institution, in this case the Civil Police of Rio de Janeiro city, are evident in the regional composition of the sample of passports (see Table 2). Since the passport records pertain to individuals travelling from the port of Rio, it comes as little surprise that the majority of the individuals included in the sample hailed from Rio de Janeiro and the Southern region of Brazil. Those born in the port city of the Districto Federal (Rio de Janeiro city) were the most abundant. In spite of this regional concentration, there is a significant portion of individuals from the North and Northeast in the sample. Since the place of

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TABLE 2
PASSPORTS SAMPLE STATISTICS

All figures are numbers of cases by 5-year cohort of birth										
Birth cohort	**1865**	**1870**	**1875**	**1880**	**1885**	**1890**	**1895**	**1900**	**1905**	**1910**
Total cases	433	1,002	1,092	2,117	2,389	1,933	1,609	2,725	1,044	663
Males	6	129	348	491	729	967	1,040	716	285	61
Females	.	29	36	45	64	109	255	211	49	16
Occupational category										
Elite	.	35	71	111	195	196	219	117	33	14
White collar	2	23	59	90	144	162	285	231	120	29
Skilled manual	1	75	234	315	475	637	632	460	137	19
Unskilled	.	23	49	71	94	126	183	138	39	8
Region										
North	.	6	6	13	23	25	33	21	3	.
Northeast	1	20	46	66	116	127	132	84	48	8
Centerwest	.	.	.	.	2	3	1	1	1	.
Southeast	1	98	240	324	502	657	799	586	215	50
South	.	17	46	83	103	113	166	101	27	6

Source: Anthropometric data, see text.

embarkation for these passport bearers differed vastly from their place of birth, I assume that all of the Northern and Northeasterners were migrants, and since the likelihood of being a migrant may have involved some selection based on human development, their heights may not be reflective of the North and Northeastern populations at large.

4. RESULTS

4.1 Military Sample

For periods in which there was no MHR to enter the military (i.e. for those inducted before 1916), ordinary least squares (OLS) regressions estimate the height trends. For soldiers inducted after 1916 when the MHR existed, regressions using truncated maximum likelihood methods to account for truncation provide reliable estimates (Komlos 2004)[6]. Due to the abundance of recruits with heights below the 155 cm MHR in the latter period, the regression models consider these periods together, using 154 cm as the presumed truncation point. Using OLS and truncated ML regressions as appropriate, I estimate regressions of the following form:

$$\text{Height} = \beta_0 + \beta_1\ \text{Cohort} + \beta_2\ \text{Skin\_colour} + \beta_3\ \text{Occupation} + \beta_4\ \text{Region} + \beta_5\ \text{Age} + \varepsilon.$$

In order to capture temporal trends in health, birth cohort is the explanatory variable of interest, while dichotomous «dummy» variables for skin colour, occupation, region and younger ages control for individual observable characteristics that may bias the estimates. During the study period, there was a shift in population concentration from the Northeast to the Southeast of Brazil. By including region dummy variables, the regressions capture the birth cohort effects within each particular region, not between them. In other words, the regressions are able to disentangle much of the bias associated with the general shift of the population to the southern regions of Brazil (in which conditions were generally more salubrious)[7].

Results from the baseline regression model appear in Table 3. Setting the skin colour, occupation, region and young-age dummy variables to zero, the birth cohort coefficients indicate that average stature hovered around 166 cm from 1860 to 1880. In 1880, stature reached a low of 165.8 cm. By 1920, the estimate from column 2 indicates that stature increased to 168.6 cm.

[6] I use Stata's truncreg command for these specifications.

[7] Though not supplied here, using state dummy variables does not change the results much. The use of robust standard errors clustered at the state level similarly does not change the results.

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TABLE 3
REGRESSIONS OF MILITARY SAMPLE

	OLS	Truncated ML
Recruitment period	**Pre-1916**	**After 1916**
Variables		
Constant	166.8***	166.6***
Cohort1860	–0.774* (0.40)	
Cohort1870	–0.145 (0.40)	
Cohort1880	–0.971*** (0.37)	
Cohort1890	–0.41 (0.44)	0.256 (1.27)
Cohort1900		0.659 (1.28)
Cohort1910		1.771 (1.28)
Cohort1920		1.992 (1.28)
Cohort1930		1.153 (1.30)
Cohort1940		2.319* (1.30)
Cohort1950		2.925** (1.29)
Black	0.562* (0.30)	0.0771 (0.25)
Mixed	–0.165 (0.22)	–0.451*** (0.13)
Amerindian	–0.817 (0.51)	–1.283 (0.78)
Farmer	1.377 (1.57)	0.750*** (0.20)
Domestic_serv	0.831 (1.57)	0.109 (0.61)
Transport	0.66 (1.15)	0.723** (0.30)
Commerce	0.521 (0.73)	0.680***(0.23)
Manufacture	0.0449 (0.32)	0.473**(0.20)
Govt_libprofs	1.431*** (0.48)	0.956*** (0.21)
Age 17	–4.142*** (0.54)	–0.975 (0.61)
Age 18	–3.209*** (0.38)	–1.128*** (0.35)
Age 19	–2.429*** (0.37)	0.179 (0.24)
Age 20	–0.909*** (0.34)	–0.336 (0.22)
Age 21	–0.474 (0.30)	–0.366* (0.21)
Age22	–0.324 (0.31)	–0.224 (0.20)
North	–3.229*** (0.68)	–5.054*** (0.35)
Southeast	–1.184*** (0.35)	–0.495*** (0.19)
Centerwest	–2.346*** (0.59)	–0.712** (0.30)
Northeast	–2.834*** (0.27)	–3.027*** (0.21)
Constant	166.8*** –0.437	166.6*** (1.27)
Sigma		5.987*** (0.05)
Weights	Occup. and region	
Observations	5,214	10,983

$^{***}P < 0.01$, $^{**}P < 0.05$, $^{*}P < 0.1$.
Source: Anthropometric data, see text.

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The variables on race, occupation and region help assess the evolution of inequalities in health. The regression results appear to be somewhat desultory in terms of racial differentials in column 1. In this specification, the black dummy returns a value of 0.562 ($P < 0.1$) with respect to whites, seeming to belie our understanding of health differentials between blacks and whites in Brazil prior to abolition. The difference between racial categories becomes more accentuated (and takes on expected signs) in column 2, where the mixed-race dummy coefficient is –0.451 ($P < 0.01$) compared with whites.

Government/liberal professionals were 1.43 cm taller than unskilled soldiers in column 1, but this premium declined over time. In column 2, the government/liberal professionals dummy returns a value of only 0.956 ($P < 0.01$), indicating that social inequalities in height diminished somewhat over the first half of the 20th century.

Highly statistically significant across all of the specifications in Table 3 are the region dummy variables. In column 1, compared with those from the South, soldiers from the North display a height disadvantage of 3.23 cm ($P < 0.01$), while those from the Northeast were 2.83 cm shorter ($P < 0.01$). In column 2, the coefficient of the North increases to 5.05, while that of the Northeast increases to –3.03. From 1850 through 1950 soldiers from the North and Northeast were systematically shorter than those from the South and Southeast. Table 4 provides a closer look at regional trends in height by birth cohort (limited only to the post-1916 sample); Figure 3 plots the birth cohort fitted values.

4.2 Addressing Potential Confounders

This section discusses potential factors that might confound the trend results presented in the preceding section. One source of concern stems from the transition from a military recruitment model based on impressment in the 19th century to one based on universal conscription after 1916. Furthermore, a wave of international migration surged to Brazil in the late-19th and early-20th centuries, roughly contemporaneously with the increase in height shown in Table 3. Table 5 presents a set of adjusted regressions that modify the baseline model in order to consider the robustness of the results to these alternative hypotheses.

In order to neutralise the bias originating from the transition from impressment to a more egalitarian service model, all of the specifications consider only those inducted after 1916. Specification 2 serves as a validity check and includes only soldiers of 19 years of age upon enlistment. Specifications 3 and 4 only include those soldiers with common surnames in order to distinguish the effects of international migration from that of some endogenous change in health within Brazil. Limiting to common

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TABLE 4
TRUNCATED ML REGRESSIONS BY REGION: AHEX DATASET

Dep. Var. Height (cm)	1	2	3	4
Variables	**North**	**Northeast**	**Southeast**	**South**
Cohort1870	0.294	0.315	–0.0220	0.218
Cohort1880	–2.152	–0.779**	0.219	–1.298**
Cohort1890	–1.861	–0.704**	1.826***	0.0608
Cohort1900	–1.529	–0.744*	2.512***	0.862
Cohort1910	1.125	2.887***	2.946***	1.922***
Cohort1920	2.214	2.314***	3.275***	1.620**
Cohort1930	4.375	2.587***	2.406***	–1.050
Cohort1940	3.769	2.379***	3.198***	5.687*
Cohort1950	6.121**	3.687***	3.862***	0.494
Urban	0.570	0.222	–0.358**	0.280
Age 17	–0.534	–0.582	0.180	–3.506***
Age 18	1.110	–2.708***	–0.817*	–2.017***
Age 19	–0.522	0.255	–0.204	–0.145
Age 20	1.981**	–0.701**	–0.299	–0.558
Constant	162.5***	163.7***	165.4***	166.8***
Sigma	5.856***	6.233***	5.911***	6.389***
Observations	783	5,857	5,509	2,501

***$P < 0.01$, **$P < 0.05$, *$P < 0.1$.

Notes: All specifications pertain to truncated ML regressions assuming a MHR of 154. Omitted categories are rural soldiers, 21 and older and born between 1850 and 1869.

Source: Anthropometric data, see text.

surnames, the regressions likely exclude the children many of the non-Iberian immigrants that entered into Brazil[8]. Many of the immigrants themselves did not join the army, but their children born in Brazil (or those that migrated at a young age) may have been recruited or conscripted. Since these recruits may have originated from families of immigrants with superior health and nutritional status upon entering Brazil, their heights are less indicative trends within the Brazilian-born families.

Specification 1 corroborates the time trends presented in the regional dummy model presented above; there was sustained growth in height from 1880 to 1910. Specification 2, related to soldiers of 19 years of age,

[8] Unfortunately, since there is such a large convergence between Spanish and Portuguese surnames, it is difficult to distinguish between any recent Spanish arrivals in Brazil from any Brazilian-born individuals.

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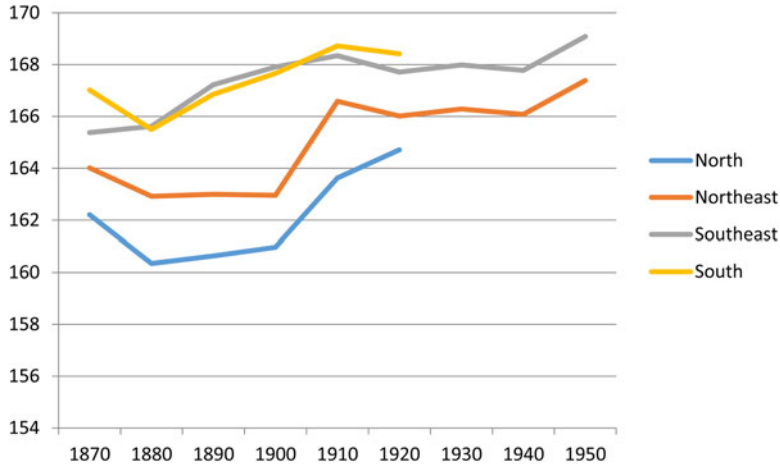
FIGURE 3
TRUNCATED ML REGRESSIONS BY REGION AND COHORT OF BIRTH.



Source: Fitted values, Table 4.

verifies the upward trends illustrated in Figure 8. As we can observe in the cohort estimates, between 1890 and 1910, there was an increase in stature of 5.2 cm. By keeping age constant, we are able to more adequately extract any time-varying effects of age from the trend estimates. Holding age constant reveals an astounding height increase, pointing to a radical improvement in health between 1890 and 1910.

Even excluding uncommon surnames, there was an increase in height of over 4 cm between 1880 and 1910 (Specification 3). The magnitude of the increase is greater than that of in the baseline specification, suggesting an upsurge in stature independent of effects from immigration. Specification 4 applies this method to soldiers with common surnames and of 19 years of age. We can see that this strengthens our results; between 1890 and 1910, there was an increase in the decadal height estimates of 6.2 cm. In sum, adjusting the regressions to account for alternative hypotheses substantiates the upward trends in stature displayed in the baseline regressions.

4.3 Passports Sample

Since an overwhelming majority of the passport bearers included in the sample were elite individuals, professionals or skilled workers, it is not surprising that the heights of the passport bearers follow a different trajectory than that of the military sample. OLS regressions are appropriate for use in the passports sample since there was no minimum height requirement for

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TABLE 5
ROBUSTNESS: TRUNCATED ML REGRESSIONS ON POST-1916 SUBSAMPLE

Dep. Var. Height (cm)	**1**	**2**	**3**	**4**	**5**
Variables					
Cohort1880	−1.397		−2.503		
Cohort1890	−0.576**	−3.817**	−0.412	−5.025***	
Cohort1900	ref.	ref.	ref.	ref.	
Cohort1910	1.353***	1.407**	1.580***	1.207	0.364
Cohort1920	1.478***	2.050***	1.822***	1.514**	
Cohort1930	0.536*	0.318	1.104***	0.561	
Cohort1940	1.437***	1.623***	1.669***	1.571**	
Cohort1950	2.037***	1.941***	2.471***	2.164***	
Urban	−0.240*	−0.197	−0.302*	0.0474	−1.064*
North	−5.375***	−3.678***	−4.683***	−3.778***	−4.080***
South	ref.	ref.	ref.	ref.	ref.
Southeast	−0.524***	−0.574	0.330	0.189	−1.219***
Centerwest	−0.662**	−0.561	0.227	0.0833	−2.815**
Northeast	−3.113***	−1.804***	−2.138***	−0.917	−3.343***
Age 17	−0.845		−0.0992		
Age 18	−0.964***		−0.589		
Age 19	0.298		0.272		1.185
Age 20	−0.247		−0.200		−0.123
Constant	167.6***	167.6***	166.3***	166.5***	169.8***

TABLE 5 *(Cont.)*

Dep. Var. Height (cm)	**1**	**2**	**3**	**4**	**5**
Sigma	6.007***	5.783***	5.888***	5.775***	5.919***
Observations	11,013	2,976	7,341	2,063	1,143

***$P < 0.01$, **$P < 0.05$, *$P < 0.1$.

Notes: Specification 1 refers to only recruitment regimes 2 and 3 assuming the MHR remained at 154 cm throughout; Specification 2 repeats this operation but limits the sample only to 19-year-old soldiers; 3 uses the same framework but limits the sample to those soldiers with common surnames only; 4 repeats the operation, but limits the sample to common surnames and 19-year-olds. Reference categories for all specifications are rural soldiers from the South, 21 years or above, and born between 1900 and 1909. Specification 5 uses only the FEB (WWII) recruits to verify consistency of regional patterns. The reference categories for this specification are rural soldiers from the South, 21 years of age or older, born between 1920 and 1929.

Source: Anthropometric data, see text.

TABLE 6
REGRESSIONS: PASSPORT BEARERS

Dep. Var. Height	**(1)**
Variables	**Height**
Cohort1875	–0.116
Cohort1880	0.907
Cohort1885	0.786
Cohort1890	0.604
Cohort1895	0.821
Cohort1900	0.844
Cohort1905	1.869*
Cohort1910	1.636
Unskilled	–6.240***
North	0.679
Northeast	–0.191
Centerwest	–1.611
South	–0.229
Age 17	–0.157
Age 18	0.323
Age 19	–1.390
Age 20	1.764**
Constant	168.6*** (0.648)
Observations	4,400
R^2	0.088

***$P < 0.01$, **$P < 0.05$, *$P < 0.1$.
Source: Anthropometric data, see text.

travel. Table 6 regresses height on dummies for cohort of birth, occupation, skin colour and region. Omitted categories are skilled/professionals, 21 years-of-age or older, from the Southeast and born between 1870 and 1874. Setting the unskilled, region and young-age dummies to zero, the birth cohort coefficients indicate stagnation in height until the 1905 birth cohort. Highly statistically significant is the dummy variable for unskilled workers, which returns a coefficient of –6.2, implying substantial inequality in height between unskilled and skilled/professional workers. The persistence of hired wet-nursing might explain this stagnation in the heights of upper- and middle-class individuals. Late-19th century officials such as the physician José Pereira do Rêgo (1878), the Barão do Lavradio, lamented that the practice of hired wet-nursing was fairly

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TABLE 7
HEIGHTS OF BRAZILIAN AND FOREIGN-BORN MALE PASSPORT BEARERS

Country	N	Mean	SD	25%	Median	75%	Min	Max
Brazil	3897	168.68	6.98	164	169	173	138	193
Portugal	276	168.554	7.18	163	168	173.5	151	188.5
Germany	105	168.08	7.42	165	168	173	144	184
Spain	23	166.435	6.96	162	165	172	156	183
Russia	49	168.54	5.96	164	168	174	154	179
Poland	29	168.14	8.14	165	170	174	146	184

Source: Anthropometric data, see text.

universal amongst the middle and upper classes, and historians sustain it remained common amongst these socio-economic groups until dried milk emerged in Brazil the 1930s (Bosi and Machado 2005). Hired wet-nursing implied that infants forwent the intake of colostrum, which contains important antibodies to resist infection in the first few days and weeks of life. Furthermore, a woman's body assumes that she is nursing the same baby as time goes on, and micronutrient content of breast milk diminishes over time, so those that were breast-fed by wet-nurses received less-quality milk than they would have otherwise.

The passports sample also allows for an analysis of the effects of immigration on Brazil's height trends. Table 7 displays the height distributions of Brazilian- and foreign-born male passport bearers. The median height of Brazilian-born male passport bearers is 169 cm, a value higher than the median for all other nations except for Poland (median = 170 cm). Based on this cross-sectional comparison, we can sustain that immigration to Brazil during the late-19th and early-20th centuries did not account for the marked upswing in stature observed over the 1880–1910 interval in the previous chapter focused on the military dataset.

5. BRAZILIAN HEIGHTS IN COMPARISON

This section places the estimates from the military dataset in comparison. Figure 4 compares the height estimates from the military and passport samples with existing historical height estimates for Brazil. Comparing the time trends of the passport bearers with those of the soldiers, we observe socio-economic convergence in height during the study period. This is a rather interesting finding since income differentials normally widen in the initial phase of industrialisation (Kuznets 1955). It would appear that the socio-economic health gap improved with the efforts of the Republican state (discussed below in Section 6).

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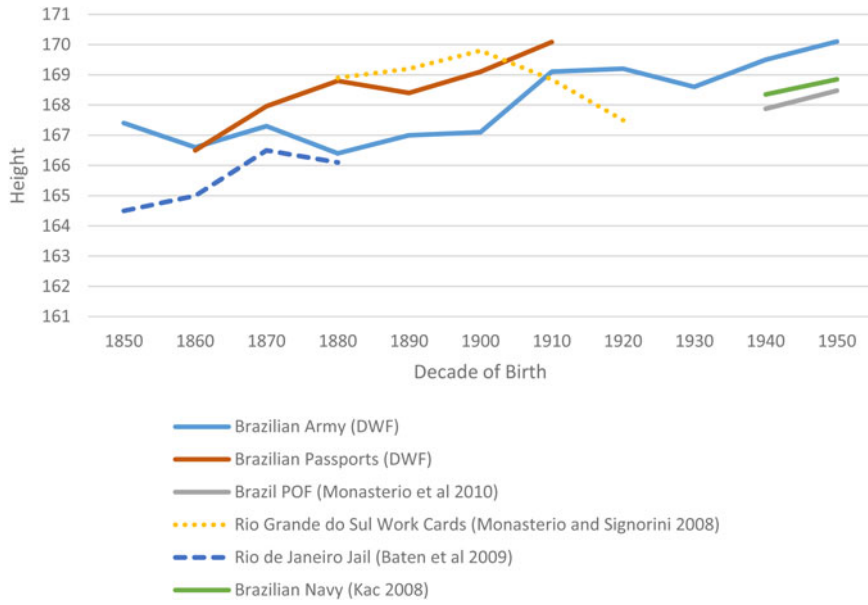
FIGURE 4
HISTORICAL HEIGHTS OF BRAZIL IN COMPARISON.



Source: Anthropometric data, see text.

Data from the Rio de Janeiro city jail for the 19th century indicate a slight, positive upward trend from 1860 to 1880 (Baten *et al*. 2009). The means of soldiers are somewhat greater than the average from the military sample. If the regressions performed here had used prison data similar to those found in Frank (2006) and Baten *et al*. (2009), the region dummy coefficients would yield a less accurate vision of regional health inequalities. The authors using prison records to study Brazil's historical height trends reveal a regional pattern by which heights from the North and Northeast Brazilian provinces advanced at a quicker rate and reached a higher average height by 1880. Despite the intriguing upward trend, I argue that prison records overstate the height of individuals hailing from the northern regions. Higher heights of Northern and Northeasterner prisoners likely reflected their immigrant status: individuals born in the North and Northeast that were physically capable of making the arduous journey to the Southeast (or that had the disposable income to pay for a ticket to travel by ship) were likely more robust and taller than non-migrants. Since they are more likely to observe individuals in or near their area of birth, military records offer a more reliable source of evidence to study historical heights in Brazil during the period in question.

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Other historical heights studies on Brazil in the 19th and 20th centuries have relied on worker registration cards from the state of Rio Grande do Sul. Intriguingly, whereas military records reveal improvement in stature over the 1880–1910 interval, Monasterio and Signorini (2008) use worker registration cards from Rio Grande do Sul and exhibit relative stagnation in height, with annual averages vacillating between 168.9 and 170.2 cm from 1889 to 1914, and a steady decline in height beginning in 1915. The higher overall stature from the registration cards is likely a product of better environmental conditions that inhibited the proliferation of disease and increased opportunities for animal protein consumption; Rio Grande do Sul, a traditional cattle-producing area, is located in Southern Brazil in a more temperate climate. Further, the authors note that both extremes of the height distribution are likely absent in the worker registration cards, since both the poorest and the wealthiest members of Brazilian society did not use worker registration cards in this period. Notably, the authors find no agricultural workers in their sample.

National surveys on heights and nutrition in Brazil began to be collected in the 1970s, and these surveys have served as the basis for a handful of historical height estimates (Monasterio *et al*. 2010). The IBGE proclaims that the *Pesquisa de Orçamentos Familiares* (POF, Family Budget Survey) microdata are representative of the Brazilian population as a whole, and the random sample of 40,000 men in birth cohorts ranging from 1940 to 1980 deviate only slightly from the military sample (although somewhat reduced in stature). These surveys are more cross-sectional in nature, and as such, estimates for earlier cohorts are based on older adults and subject to bias. The trends for that period based on army soldiers are also similar to findings from naval recruit records, although statures of the navy recruits discussed by Kac (1998) were somewhat smaller. Specifically, for the pre-1940 period, the Brazilian military appears to be the least biased source for historical anthropometric research.

6. DISCUSSION

6.1 Time Trends

Three main periods can be delineated when we examine trends in height of the military data sample. First, heights in the military sample of soldiers born between 1850 and 1880 exhibit stagnation with minor decadal fluctuations. Second, soldiers in the cohorts of birth from 1880 through 1910 illustrate a sustained increase in heights of over 3 cm. Third, heights for those born in the 1920s remained constant before falling slightly for those born in the 1930s, while those in the 1940 and 1950 birth cohorts demonstrate a return to moderate growth in height, although the rate of

change in this later period does not supersede that found in the 1880–1910 cohorts. Since heights began trending upwards in the Southeast shortly after Brazil began to industrialise circa 1870 (Leff 1982), industrialisation does not appear to have had a deleterious effect on stature as it did in early-industrialising nations such as the United States. In general terms, the rapid increase in heights during the early-20th century does not correlate with what we know of economic growth during the period, especially when we consider the rapid upsurge in statue for soldiers born in the 1910 cohort from the Northeast. The evolution of heights in Brazil calls for a revised understanding of the First Republic.

Determining whether improved health or sample selection bias caused the increase in stature observed from the military series has posed one major obstacle to this study. Recalling that the transition to conscription in 1916 implied a greater concentration of age at recruitment upon 19 years, one hypothesis might attribute the increase in heights observed in 1890 birth cohort to sample-selection bias. In essence, the onset of conscription in 1916 has the potential to augment the sample population of skilled individuals, and this change would be reflected most prominently in the 1890 cohort of birth.

One can logically reject the hypothesis that sample selection accounted for the observed increase in height after considering several features of the military dataset. When compared to census data, the skill composition of the military changed relatively little. While military induction was becoming more selective in aggregate terms, this did not mean that it was becoming more selective vis-à-vis the underlying population. It is worth recalling here that the middle and upper classes avoided direct service both before and after the 1916 conscription law. In the post-1916 era, students of secondary or tertiary institutions enrolled in reservist shooting corps, which enabled them exemption from the draft (Beattie 2001). By means of membership in the National Guard before 1916, or in a reservist shooting corp thereafter, many potential recruits from the middle and upper classes consistently relied on legal safety nets in order to avoid service in the barracks.

The hypothesis that changes in recruitment practices accounted for the height increase holds little weight when we consider the region-specific time series displayed in Figure 3. If sample selection accounted for the stature increase, we would expect a generalised upswing in stature to occur across all regions simultaneously. Instead, we observe that heights began trending upwards in the South and Southeast in the 1880 birth cohort, and this period of growth came to a close in the 1910 birth cohort[9].

[9] One additional objection may attribute the lagging growth in heights to bureaucratic delay in implementing universal conscription in the North and Northeast. This hypothesis seems highly unlikely, since the Brazilian army depended on federal funding and no such delay has been discussed by military historians.

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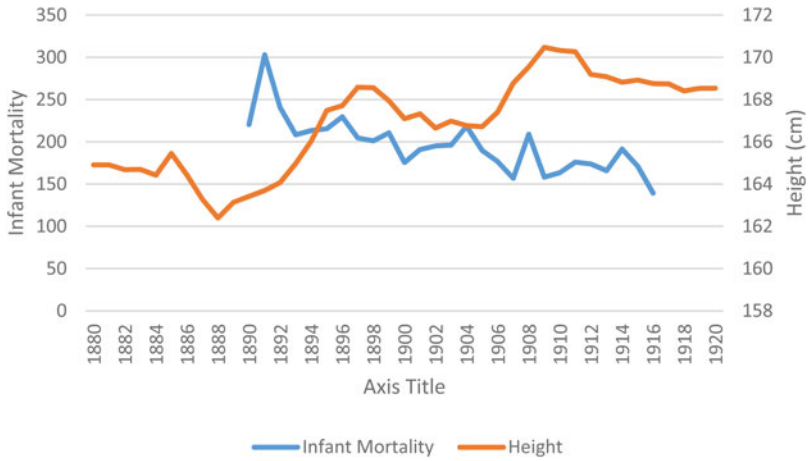
The breakdown of the height trends by region is most consistent with the imbalanced development of industry and the uneven roll-out of hygiene reforms across Brazilian regions. One potential explanation for the earlier upward trend in the South and Southeast is that hygiene reforms initially focused on health concerns in urban areas, and these efforts were concentrated in the key area of economic growth—the Southeast coffee sector. Scholars have also argued that early hygiene reforms sought to secure the inflow of immigrants rather than to improve health for broader humanitarian purposes (Rezende and Heller 2002). Early measures included the expansion of sewage networks, regulation of foodstuffs, drainage of swamps and inspection of buildings for rain-water cisterns or stagnant water—the breeding grounds for yellow fever and malarial mosquitos (Hochman 1995).

In the southern regions, there were also campaigns to improve infant childcare in Brazil emerged in Rio de Janeiro in the 1880s with the establishment of well-baby clinics, wet-nurse inspections and the *gottas de leite*, or urban milk distribution centres (Otovo 2009). Marking a disjuncture with the *ad hoc* methods disease control that prevailed during the Empire, the 1889 bill on public health and sanitation centralised and modified sanitation codes and medical care (Meade 1997). The government executed urban and rural hygiene reforms in the 1900s and 1910s, focusing first on sanitation and clean-water technologies in urban areas and then on rural sanitation, respectively. The upward height trends in the 1910s in the North and Northeast coincide with the timing of public health interventions in rural areas. In the 1910s and early 1920s, the efforts of the hygienist movement shifted to rural health campaigns aimed at eradicating hookworm, malaria and Chagas disease (Hochman 1995).

These measures enacted in the initial decades of the First Republic have not been sufficiently analysed with quantitative research. While I do not present direct causal evidence here, disease-specific mortality data substantiate the timing of the upward height trends.

The evolution of heights correlates with the limited knowledge we have of demographics and the burden of disease. The infant mortality rate is widely reflective of prevailing hygienic conditions. Official statistics on the infant mortality rate are available for Rio de Janeiro, and while we cannot consider the case of the city as universal throughout Brazil, historical scholarship tends to suggest that other municipalities in the southern regions were not far behind the Rio-model in terms of public-health interventions. As we can see in Figure 5, there was a precipitous decline in the infant mortality rate in Rio de Janeiro, dropping from an average of roughly 250 in the early 1890s to less than 150 per thousand by 1915. This decline of roughly 40 per cent in the infant mortality rate denotes a radical improvement in hygienic conditions when we consider some international comparisons. Alsan and Goldin (2015) find a decline in infant

FIGURE 5
INFANT MORTALITY AND HEIGHTS IN RIO DE JANEIRO.



Source: Anthropometric data from AHEX for heights. The series was computed using the 3-year moving average by year of birth for soldiers born in Rio de Janeiro. Brasil (1926) for infant mortality.

mortality in the Boston metropolitan area from 175 per 1,000 in 1880 to 110 per 1,000 in 1915 for urban areas that received both sewage and clean water services. The decline in infant mortality in Rio de Janeiro is relatively consistent with the increase in stature in southern regions, pointing to an improvement in the disease environment.

Other demographic indicators are also consistent with the height trends. Crude death rates began to decline around the same time that heights began their upward trend. While births per thousand population remained relatively high and stagnant until 1920, deaths per thousand population declined steadily in the late-19th century, from 32.3 in 1840–1870 to 26.4 at the dawn of the 20th century (Merrick and Graham 1979, p. 37).

The *Annuario de Estatística Demographo-sanitaria*—an especially rich yet underexploited compilation of health statistics for Rio de Janeiro—reveals that parasitic and infectious diseases fell by 43 per cent between 1904 and 1910 (Adamo 1986, p. 122), and this improved epidemiological environment likely accounted for the upsurge in stature.

Death rates from dysentery, typhoid and malaria also aid in understanding the upward trend in heights in the 1880–1910 period. Although malaria is not directly related to nutrition *per se*, economic historians have found an association with the burden of malaria in a given locale and soldiers' heights. In the 19th-century United States, Hong (2007) notes a marked

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negative correlation between the incidence malaria and heights of Union Army Soldiers. In cities in the Southeast, public-health initiatives focused on malaria, yellow fever and the plague began in the 1890s. Pools of stagnant water and cisterns used to collect rainwater for drinking represented the main breading grounds for malarial mosquitos. Available statistics for Rio also indicate a substantial decline in disease-specific mortality rates during this period. In the early 1890s, the mortality rate from malaria oscillated between 300 and 500 deaths per 100,000 residents, yet by 1905 this figure had dropped to well under 100 deaths per 100,000. Prior to the 1890s in Rio de Janeiro, yellow fever resulted in the death of nearly five per 1,000 residents. By 1904, yellow fever mortality fell to virtually zero (Brasil 1926).

Beginning in 1902, the coordinator of Brazil's first major public health campaigns, Oswaldo Cruz, enacted a series of reforms that began in Rio de Janeiro and were later extended to other areas. In Rio de Janeiro, a newly-created brigade of sanitary police specifically designated to enforce public health laws began to conduct inspections of homes for improper waste disposal, stagnant puddles and cisterns for rainwater collection—hotbeds of infectious diseases such as the plague, yellow fever and malaria. Part and parcel of the reforms entailed the Pereira Passos urban renewal schemes from 1902 to 1906. During that time, despotic slum-clearance methods implied the destruction of several hillside tenements and favelas (informal urban settlements) near the central business district, which displaced roughly 40,000 residents to make way for Parisian-style avenues, an expanded port and an opulent opera house. Historians have widely attacked the early-20th-century public health campaigns orchestrated by, arguing that the methods of slum clearance were oriented towards beautifying the city rather than producing concrete gains in health (Needell 1987). However, heights and other data illustrate that the health campaigns of the early-20th century enjoyed considerable success. Evidence on the United States suggests that the least well-off members of society benefited most from clean-water interventions in the early-20th century (Troesken 2002). The case of Brazil appears to be consistent with this, since there is little upward trend in height of the more well-off passport bearers in the early-20th century.

6.2 Regional Discrepancy

One striking feature of the military heights sample is the persistent regional inequality in heights seen in Figure 3. A myriad of factors can explain such persistent regional inequality in height. Dietary patterns can give us a general idea of the quality and quantity of high-quality proteins and micronutrients typically consumed by region. Beans, rice and coffee were staples

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that were fairly ubiquitous across regions during this period (Castro 1952). Nineteenth-century records show that Northeasterners tended to consume higher amounts of dried beef (*carne seca* or *carne do sol*), whilst inhabitants of the South and Southeast consumed higher amounts of fresh vegetables and meats (Baten *et al*. 2009). Salting and solar radiation have been proven to drastically lower the micronutrient content of beef (Kipple 1989). The seminal reference on nutrition in Brazil, «The Geography of Hunger» (Castro 1952) asserts that the North Amazon territory had fewer natural sources of animal proteins, and the region's endemic plant species have considerably fewer of the most important micronutrients for adequate diet. The sugar-producing and arid areas of the Northeast historically had a similar lack of quality animal protein. Contrastingly, the more temperate zones of the South and Southeast provided conditions more hospitable to agricultural production and cattle raising.

In sum, although the analysis of the military samples presents some difficulties, it provides the best glimpse of Brazilian population health before the mid-20th century. The changes in recruitment practices do not appear to have introduced great bias in the sample, and the evolution of heights across regions squares well with what we know of public efforts to eradicate major diseases such as malaria and hookworm. Further, immigration to Brazil does not appear to have been a major factor in the upward height trends discovered in the late-19th century.

7. CONCLUSION

This paper discusses the evolution of stature in Brazil from 1850 to 1950. Data on human height of soldiers illustrate substantial improvements in public health associated with the transition to the First Republic. OLS and truncated ML regressions estimate the time trends and covariates of height, indicating a dramatic increase in stature in the first decades of the 20th century.

Robustness checks considering alternative hypotheses corroborate the upward trends depicted in the baseline regressions. Considering soldiers inducted after the onset of universal conscription reveals the same 3 cm increase in stature. When the regressions are limited to only soldiers with common surnames, the cohort estimates reveal a 4 cm increase in height. Restricting the sample to only 19-year-olds and those with common surnames indicates that the increase in stature between 1890 and 1910 was 6.2 cm. At the same time, the heights of passport-bearing males remained relatively stagnant from 1870 to 1910, indicating that there was socioeconomic convergence in stature in the early-20th century.

The height data presented in this paper suggest that public efforts to improve early life health enjoyed considerable success in Brazil in the

late-19th and early-20th centuries. In the late-19th century, *gottas de leite*, urban milk distribution centres, emerged to provide pasteurised milk to poor families, but they also brought many working-class women into direct contact with medical physicians, allowing for greater dissemination of knowledge regarding bacteriology and sterilisation. Poor hygiene and sanitation, coupled with under- and malnutrition, were likely the main factors underpinning lower overall stature in the 19th century, prior to the modern, industrial era. The innovations in sanitation and public health services that emerged during the First Republic lessened the burden imposed by infectious diseases and increased heights. In Rio de Janeiro, official mortality statistics illustrate a pronounced decline in per capita mortality from diseases such as malaria in the period of observed height increase.

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