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Growing Taller, yet Falling Short:

Policy, Health, and Living Standards in Brazil, 1850-1950

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in History

by

Daniel William Franken

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ABSTRACT OF THE DISSERTATION

Growing Taller, yet Falling Short:

Policy, Health, and Living Standards in Brazil, 1850-1950

by

Daniel William Franken

Doctor of Philosophy in History

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Professor William R. Summerhill, Chair

The emergence of regional inequities and the genesis of modern economic growth 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. My dissertation 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.

Heights offer an excellent source of knowledge regarding human development for Brazil in the 1850-1950 period—an era of deep social, political, and economic transformations. My analysis centers heavily on a large (n≈17,000), geographically-comprehensive series compiled from military inscription files, supplemented by an ancillary dataset drawn from passport records (n≈6,000). This dissertation also integrates reports of the Rockefeller Foundation's International Health Board (IHB), which spearheaded rural health campaigns in Brazil targeting hookworm and malaria in the 1910s and 1920s.

This thesis details the inadequacies of traditional approaches to human development for Brazil in the nineteenth and early-twentieth centuries. I rely on regression analyses to estimate the secular trends in height, consider alternative hypotheses, and assess selection biases. Venturing beyond conventional methods of historical anthropometrics, I endeavor to identify causal forces behind the observed patterns with historical climate and geographic data used to proxy for the virulence of the disease environment. I also utilize statistics on health expenditures and mortality rates in order to contextualize the observed height patterns.

I document inferior heights in the North and Northeast that predated the advent of industrialization. At the national level, my findings reveal a 3-centimeter stature increase from 1880 to 1910, a growth rate commensurate with that observed in more industrialized economies in the latter-twentieth century. 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. I show that, although rural sanitation in the early-twentieth century improved health conditions, administrative shortcomings hemmed down the rollout of modern health institutions and continued to plague the nation.

The dissertation of Daniel William Franken is approved.

Dora Luisa Costa

Mary A. Yeager

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Introduction

This dissertation examines the evolution of trends in health and living standards in Brazil in the nineteenth and twentieth centuries. Health and nutrition are integral components of living standards. As such, this thesis relies on an indicator that reflects both nutritional and health conditions: human heights. This dissertation asks two main questions: 1) Did changes in economic and social policy imply an improvement in human development in the late-nineteenth and early-twentieth centuries? 2) How did regional inequalities in human development evolve over time?

The period under investigation here, 1850-1950, was one of deep social, political, and economic transformations in Brazil, yet we know little about how such changes shaped human health. As we shall see, this period bore witness to a shift in comparative advantage from sugar to coffee; an accelerated rate of economic growth largely fueled agro-exports; the abolition of slavery and the transition to a wage-based labor regime; industrialization; institutional modernization; massive immigration from abroad; and the transition to republican governance after nearly 7 decades of post-independent, monarchical rule. While historians have amply studied singular instances of these transitions, the lack of direct evidence on human welfare has precluded a full understanding of their impact.

The region studied herein encompasses the entirety of the Brazilian territory. Such a broad geographic coverage contrasts with other approaches to studying trends in health and living standards involving locally-derived data (i.e., income series culled from company registries, or vital statistics limited to one city or locale). Within the vast expanse of the Brazilian territory there are immense differences in climate and geographic endowments, and this dissertation subscribes to the official conventions of regional divisions.[1] The Northern region of the country is one of tropical conditions, while tropical and semi-arid conditions prevail in the Northeast. The climate of the Southeast is sub-tropical, while the South is more temperate. Debates on regional inequality in the present day indicate that the Northern regions are lagging behind the Southeast in terms of social and economic development. Contemporary inequalities in income and health cut across regions and social groups, but the onset and causes of these disparities have remained elusive to scholars of Brazil due to a dearth of historical evidence on human welfare before the mid-twentieth century.

In cross-sectional growth analyses, some scholars argue that close proximity to the equator limited technological development and retarded the demographic transition.[2] Other researchers suggest that levels of inequality during colonial periods were the most salient factors in determining the extension of public goods that fomented economic development.[3] The cross-country growth literature has also assessed the direct geographic underpinnings of subsequent economic outcomes,[4] yet few country-specific studies explore political and geographic factors underlying ill-health and poverty in long-term

[1] The states are divided by region as follows: North—Acre, Amapá, Amazonas, Pará, Rondônia, Roraima, Tocantins. Northeast— Alagoas, Bahia, Ceará, Maranhão, Paraíba, Pernambuco, Piauí, Rio Grande do Norte, Sergipe. Central-West— Goiás, Mato Grosso, Mato Grosso do Sul, Distrito Federal (Brasília). Southeast—Espírito Santo, Minas Gerais, Rio de Janeiro, São Paulo. South— Paraná, Rio Grande do Sul, Santa Catarina.

[2] Jeffrey D. Sachs, "Tropical Underdevelopment," *NBER Working Paper* 8119 (February 2001).

[3] Stanley L. Engerman and Kenneth L. Sokoloff, *Economic Development in the Americas since 1500: Endowments and Institutions* (New York: Cambridge University Press, 2012); D Acemoglu, S Johnson, and J A Robinson, "The Colonial Origins of Comparative Development: An Empirical Investigation," *The American Economic Review* 91, no. 5 (December 2001): 1369–1401.

[4] N Nunn and N Qian, "The Potato's Contribution to Population and Urbanization: Evidence from a Historical Experiment," *Quarterly Journal of Economics* 126, no. 2 (2011): 593–650; N Nunn and D Puga, "Ruggedness: The Blessing of Bad Geography in Africa," *Review of Economics and Statistics* 94, no. 1 (2012): 20–36.

perspective. Within Brazil in particular, some historians point to the types of commodities exported by the Northeast and the Southeast, which were predominantly sugar and coffee, respectively.[5] Others point to the concentration of technological development in the Southeast, where industrialization began circa 1870, as the genesis of the wedge between the regions. Despite a general consensus that regional inequities formed at some point in the mid- to late-nineteenth century, we have a limited understanding of the beginnings and causes of Brazil's regional divergence. An analysis of long-term trends in living standards across regions, as well as the distinct environmental conditions influencing such patterns, will enrich our understanding of regional underdevelopment in Brazil.

This dissertation is the first effort to construct a nationally-representative database to quantify changes in human development in Brazil (before the 1940s). Where traditional indicators—namely real income per capita, life expectancy, or infant mortality—are inexistent or unreliable, anthropometric research provides a foundation to analyze longitudinal and cross-sectional variation in health trends. Anthropometric indicators have been widely used in recent decades to chart and analyze trends in living standards. Within this methodology, human height data, commonly conceptualized as a metric for "nutritional status" or "the biological standard of living," serve as the main body of evidence for this study. I constructed two large anthropometric datasets from archival sources hitherto unused for quantitative purposes: one series of over 17,000 observations culled from military inscription files and an ancillary set of over 7,000 passport records. While the military dataset tends to capture individuals from the lower

[5] Nathaniel H. Leff, "Economic Development and Regional Inequality: Origins of the Brazilian Case," *The Quarterly Journal of Economics* 86, no. 2 (1972): 243–62.

socio-economic groups, the sample of passport bearers is generally more representative of the middle and upper classes. Using these datasets, the primary goal of this dissertation is to examine the trajectory of human development in Brazil over the 1850-1950 interval. Embedded within this larger objective is the goal to identify regional and social inequalities and discuss how they evolved over time. A second objective is to explain the estimated longitudinal trends and cross-sectional patterns in height. Although this study is most heavily rooted in historical anthropometrics, it also relies on research methods used by geographers and epidemiologists. Climatic, demographic, and other supplemental statistics aid in the interpretation of the observed height trends.

Since their first use by economic historians, data on human stature have illuminated historical phenomena that were otherwise unobservable, providing a window into the nutritional and health status of difficult-to-reach populations. As we shall see, while heights offer a meaningful reflection of health and nutritional status, the implications of changes in stature are far-reaching. Anthropometricians have established a strong correlation between cognitive ability and heights, and labor economists have also linked taller stature to increased productivity.[6] Recent research also indicates a correlation between heights and mental health, suggesting that stunted individuals were less mentally stable.[7] At the end of the period in question, Brazilian soldiers born in the 1950s were some 4 centimeters taller than their predecessors born in the 1850s, and the brunt of this increase in stature took place between the decades of 1890 and 1910. In the

[6] Roderick Floud et al., *The Changing Body: Health, Nutrition, and Human Development in the Western World since 1700.* (Cambridge and New York: Cambridge University Press, 2011), 23.

[7] L H Lumey and F W A van Poppel, "The Dutch Famine of 1944-45 as a Human Laboratory: Changes in the Early Life Environment and Adult Health," in *Early Life Nutrition and Adult Health and Development*, ed. L H Lumey and Alexander Vaiserman (New York: Nova Science Publishers, 2013), 59–76; cited in Dora Costa, "Health and the Economy in the United States, from 1750 to the Present," *NBER Working Paper* 19685 (2013).

nineteenth century, soldiers hailing from North and Northeast were on average 3 centimeters shorter than their southern counterparts, and although this regional height gap decreased in the 1910s, northerners remained persistently shorter.

Political and economic considerations have remained at the forefront of the debate on economic development during this era. Moreover, the restraints on development imposed by lingering political shortcomings during and after the Imperial era (1822-1889) have been frequently debated. Many historians have criticized policy formation during the First Republic (1889-1930), arguing that Brazil's democratic process was a farce--political innovations remained captive to landed interests and did little to benefit the masses.

The extant economic history literature has been particularly concerned with the hindrances to development supposedly derived from an overreliance on agro-exports as the principal motor of economic growth. Studies rooted in dependency theory have dominated a large portion of the historiography on economic growth. For this camp, the reliance on coffee exports to core economies doomed Brazil to backwardness. Such scholars suggest that modern economic growth only began in the 1930s, when the populist leader Getúlio Vargas took power, shifting policy formation in the favor of labor and import-substitution strategies. The seminal reference on economic development during the nineteenth and twentieth centuries, however, argues that modern economic growth began with the onset of the First Republic, which augmented the amount of state investment in infrastructure, education, and public health—key avenues for economic development. Still, however, the pessimism proffered by dependency theory has permeated much of the literature on the agro-export period, which began in the final decades of the nineteenth century and lasted until the Great Depression of the twentieth century. While the literature grounded in cliometrics has elucidated the benefits wrought from the increased degree of economic regulation associated with the First Republican state, a wide range of interpretations regarding economic development during the nineteenth and early-twentieth centuries has survived, thus painting a rather opaque picture of the living conditions faced by the common Brazilian. Using data on stature, this dissertation seeks to clarify these questions related to human and economic development in nineteenth- and twentieth century Brazil.

In addition to factors related to political economy, scholars have indicated that policies implemented during the First Republic also increased involvement in in the realm public health. The hygiene movement that emerged in Brazil in the early-twentieth century has received some scholarly attention; however, evaluations of the effectiveness hygiene reforms have been limited to qualitative evidence, and the paucity of direct data has inhibited a full understanding of the human-health consequences of hygiene reforms. Based on the height evidence presented herein, I argue that the increased state involvement in health and economic matters associated with the transition from the Empire to the First Republic had a beneficial impact on human development. At the same time that these efforts to propel Brazil into modernity were met with considerable success, this dissertation also reveals stark regional inequalities in the biological standard of living even after the first large-scale public health interventions which took place between the 1890s and 1920s. Despite the success of these early-twentieth-century reforms, a lack of funding and personnel hemmed down the rollout of modern health institutions, and these shortcomings in public administrative capacity continued to plague the nation. While Brazilians grew taller during the period studied here, policymakers fell short in their efforts to assure enduring prosperity.

Plan for Study

Chapter 1 provides a historical overview and reframes the standard of living debate in post-independence Brazil, placing particular emphasis on the varying interpretations of Republican period. In this chapter, I argue that the data constraints faced by previous studies on health and living standards (particularly prior to 1940) have created a large degree of ambiguity in Brazil's historical literature regarding the role of state at the dawn of the twentieth century. Chapter 2 provides a methodological background by summarizing the determinants of human stature and noteworthy studies in anthropometric history. Chapter 3 discusses military history in Brazil and presents the contours of the military dataset. In Chapter 4, I rely on regression analyses to estimate trends in height based on the military sample. Chapter 5 presents the ancillary dataset of passport bearers and also utilizes statistical analyses to estimate trends in height of the passports sample. In Chapter 6, I make comparisons of Brazil's height trends and proffer potential explanations for the observed variance in stature. In this chapter, I utilize a county-level subset of heights derived from the military sample to analyze the relationship between environmental conditions and human health. I deploy epidemiological theories to estimate the prevalence of enteric disease, and find that rainfall velocity, as a proxy for the risk of flooding, explained a significant negative influence on heights, particularly prior to the 1910 decade. Chapter 7 hones in on hookworm disease, which was particularly widespread in Brazil. This chapter incorporates reports from the Rockefeller Foundation, which conducted rural health campaigns in early-twentieth-century Brazil, and assesses the consequences of the rural hygiene movement. Lastly, I provide an overview and concluding remarks.

Chapter 1. *Bota Acima?* Reframing the Living Standard Debate in Modern Brazil

Introduction

In 1904, a law that mandated obligatory vaccinations against smallpox provoked an uproar amongst the masses of Rio de Janeiro known as the Vaccine Revolt. Angered by the first large-scale invasion of private lives by public authorities, throngs of protestors overran the city center, turning over street cars and looting small shops. Despite the contempt with which the vaccine law was met by the public, it can be seen as part of larger set of reforms related to health and hygiene that were carried out during the First Republic (1889-1930). Beginning in 1902, the coordinator of the 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 (frequently unannounced) inspections of businesses and private homes. The main targets of these inspections were areas improper waste disposal, stagnant puddles, and cisterns for rain water 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.[8]

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[8] Lilian Fessler Vaz, "Contribuição Ao Estudo Da Produção E Transformação Do Espaço Da Habitação Popular: As Habitações Coletivas Do Rio Antigo." (Dissertation, UFRJ, 1985).

The process of urban renewal in the city center is remembered as the *bota abaixo*, or casting down (or casting aside). While historians have tended to focus on the short- and medium-term adverse effects of slum clearance, it can be argued that these urban health campaigns ushered in a new era of state formation marked by increased state involvement in matters related to the economy and public health. A record of ill-health had tarnished Brazil's reputation on the international stage, and the vaccine law was emblematic of a set of reforms that aimed to place Brazil amongst the ranks of the world's "modern" nations. Modernization during the First Republic entailed higher levels of public investment in (and regulation of) infrastructure, education, public health, and sanitation. Although a legacy of semi-feudal land and labor relations endured until the Vargas era (1930-45), given the dramatic shift in social, public-health, and economic policies that emerged, one can question the common view amongst historians that the First Republic represented a failed experiment.

While the autocratic methods of slum clearance in the nation's capital are aptly remembered as the *bota abaixo*, this dissertation posits a re-framing of the standard-of-living debate in nineteenth and twentieth-century Brazil. The innovations in public policy that emerged during the First Republic sought to catapult the nation into modernity by decreasing the virulence of disease and improving opportunities for education, health, and economic progress. When viewed in light of the administrative inadequacies that prevailed during the Imperial Period (1822-1889), this dissertation will examine the hypothesis that the progressive agenda of modernizing initiatives associated with the First Republic improved the health status of the Brazilian population. If an increase in stature is detectable during this period, we might conceptualize the wider umbrella of policy changes during the First Republic as a *bota acima*, a casting up.

Although there exists a vast literature on public-health reforms during this era, few researchers have endeavored to assess the health outcomes for the Brazilian population with quantifiable evidence.[9] In light of the restrictions placed voting (which limited the vote to the literate), the high level of racial and social inequality, and the endurance of patron-client relationships, some historians have argued that policy formation during the First Republic merely served the interests of the elite. According to this interpretation, the Pereira Passos urban renewal schemes in Rio de Janeiro only favored consumption and consumerism.[10] To be sure, there were certainly negative implications for the citizens that had their hillside dwellings ripped from underneath them; however, a lack of data prevents researchers from tackling such adverse effects. Other scholars have argued that the motivation behind the public-health movement that emerged during the First Republic was not entirely altruistic, suggesting that advances in sanitation (such as piped water and sewage) were oriented towards securing the inflow of immigrants from Europe.[11] Still others highlight the ineffectiveness of the vaccination campaigns, pointing to cultural and social factors surrounding the popular discontent with the authorities' invasion of private lives.[12] Using data on human stature, an established measure of health and nutritional status, this dissertation contributes to the existing

[9] One notable exception is Sam C. Adamo, "The Broken Promise: Race, Health, and Justice in Rio de Janeiro, 1890-1940.," *PhD Diss. University of New Mexico*, 1986.

[10] Maurício de A Abreu, *Evolução Urbana Do Rio de Janeiro* (Rio de Janeiro: IPLANRIO, 1987).

[11] Sonaly Cristina Rezende and Leo Heller, *O Saneamento No Brasil: Politicas E Interfaces* (Belo Horizonte, MG: Editora UFMG, 2002).

[12] Jeffrey A. Needell, *A Tropical Belle Epoque: Elite Culture and Society in Turn-of-the-Century Rio de Janeiro* (Cambridge and New York: Cambridge University Press, 1987).

historiography on public-health and economic policies in Brazil with an empirical investigation of trends in health and well-being over the 1850-1950 period.

This chapter has two objectives. First, it seeks to acquaint the reader with a broad historical background of Brazil during the period in question. Secondly, it established the hypotheses to be tested with statistical analyses of anthropometric evidence in Chapters 3 through 6. In order to understand the importance of innovations in policy formation during the Republic, the historical overview of Brazil in the nineteenth and twentieth centuries places particular emphasis on major political, economic, and social transformations. Along with a survey of the historiography, I incorporate supplemental statistics on demographic and economic trends within the narrative of the chapter. I argue that, while much of the historiography has tended to view Brazil's First Republic as a failed experiment that had a limited impact on population health, the agenda of the Republican government was more progressive than is generally accepted.

The argument proceeds in three sections. In Section 1.1, I provide a general historical backdrop, while highlighting broad economic and social transitions in the late-nineteenth and early-twentieth centuries. Section 1.2 discusses conventional methods used to study health and living standards, their limitations, and their applications to Brazilian history. Section 1.3 concludes.

1.1 Historical Overview: Brazil's Path to Modernity

General Trends

From the sixteenth through the nineteenth centuries, Brazilian economic growth was largely centered on the sugar plantation. It was in the Northeast of Brazil that the sugar plantation economy first developed in the mid-sixteenth century, and soon after Brazil was the world's largest producer of sugar. Settlement in southeastern Brazil was more gradual, and this region remained a backwater of the colony until the late-seventeenth century, when frontiersmen discovered gold and diamonds in the southern interior (predominantly in present-day Minas Gerais, but with some mines also in the western states of Mato Grosso and Goiás). Reserves of precious metals were quickly exhausted, and after the mid-eighteenth century there was a rapid decline in mining activity. However, the legacy of the mining economy, the growth of agriculture in the provinces of Rio de Janeiro and São Paulo, and the transfer of the colonial capital from Salvador, Bahia to the city of Rio de Janeiro in 1763 solidified the importance of the Southeast as an economic and population center during the late-colonial period.[13]

Upon independence from Portugal in 1822, Brazil was governed as a constitutional monarchy until the fall of the Empire in 1889. Until roughly the last three decades of the nineteenth century, the Brazilian economy was marked by stagnation. The transfer of the Portuguese court to Brazil in 1808 brought opportunities for growth, as the court prompted several new initiatives in education, infrastructure, and manufacturing, but these changes did little to improve economic conditions. According to Nathaniel Leff, despite the high land-labor ratio that prevailed in nineteenth-century Brazil, technological constraints and high transportation costs hemmed down per capita productivity. Additionally, capital market imperfections reduced planters' and industrialists' access to credit for investment in capital stock and technological innovation. In his view, long-term growth did not commence until these bottlenecks were removed in the last decade of the

[13] Francisco Vida Luna and Herbert S. Klein, *The Economic and Social History of Brazil since 1889* (New York: Cambridge University Press, 2014). 2-3.

nineteenth century. As informational asymmetries and high transportation costs impeded aggregate growth, the endurance of the slave labor regime provided little opportunities for upward social mobility.[14] Further, there was a lack of coherent government policies concerning the living conditions of the masses. Civil accounting was inadequate, and social responsibility was not a major concern of Brazilian politics until the 1890s. Before that period social transfers for the poor emanated from private funds and charitable institutions such as the *Santa Casa de Misericórdia* (foundling homes led by the Catholic Church throughout major Brazilian cities).[15]

Given the legacy of sluggish economic growth prior to the late-nineteenth century, what can we make of the health of the Brazilian population? Although limited data on health indicators exist prior to 1940, anecdotal accounts provide glimpses of the material living conditions encountered by the common Brazilian in the nineteenth century. Observers describe a high degree of inequality in diet and a long-run, high-mortality environment that persisted through the 1800s. For example, in the early-nineteenth century, European travel writers remarked on the high amounts of meat consumed by the upper-classes, while slaves and freepersons of limited means consumed mainly beans, manioc, and occasionally jerked beef.[16] During roughly the same period, Maria Graham commented on the high level of mortality of the slave population and

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[14] Nathaniel H. Leff, *Underdevelopment and Development in Brazil: Vol. 1 Economic Structure and Change, 1822-1947.* (Winchester, MA: Allen & Unwin, 1982); Emilia Viotti da Costa, *The Brazilian Empire: Myths and Histories* (Chicago: University of Chicago Press, 1985).

[15] Maria Luiza Marcílio, *História Social Da Criança Abandonada* (São Paulo: Editora Hucitec, 1998).

[16] Henry Koster, *Travels in Brazil, 2 Vols.* (London, 1817).

estimated the rate of infant mortality to be roughly 50 percent.[17] At least until 1850 when the slave trade to Brazil was officially outlawed, planters counted on a steady inflow of slave labor to supplant the high levels of mortality. Historians have estimated that in the late-nineteenth century, infant mortality remained on the order of 30 percent in the northeastern city of Salvador.[18] As we shall see in Chapter 4, a similar rate was estimated for the city of Rio de Janeiro in the 1870s. In terms of major epidemic diseases, until the yellow fever outbreak of 1849, Brazil had been relatively free from pandemics that had grappled much of Europe and North America. Thereafter, outbreaks of smallpox, cholera, plague, and yellow fever afflicted a number of major urban centers and port cities.[19] Despite this grim view of population health throughout the nineteenth century, indicators of progress in economic growth emerged in the middle of the century.

As the performance of sugar exports waned, the coffee sector became Brazil's largest source of income over the course of the nineteenth century. Figure 1.1 displays historical trends in Brazil's leading commodity exports (sugar and coffee) from 1820 to 1940.[20] Since the Northeast specialized in sugar and the Southeast in coffee, the prices of these commodities could have impacted prevailing economic conditions between regions, and differing economic conditions could have in turn impacted stature.

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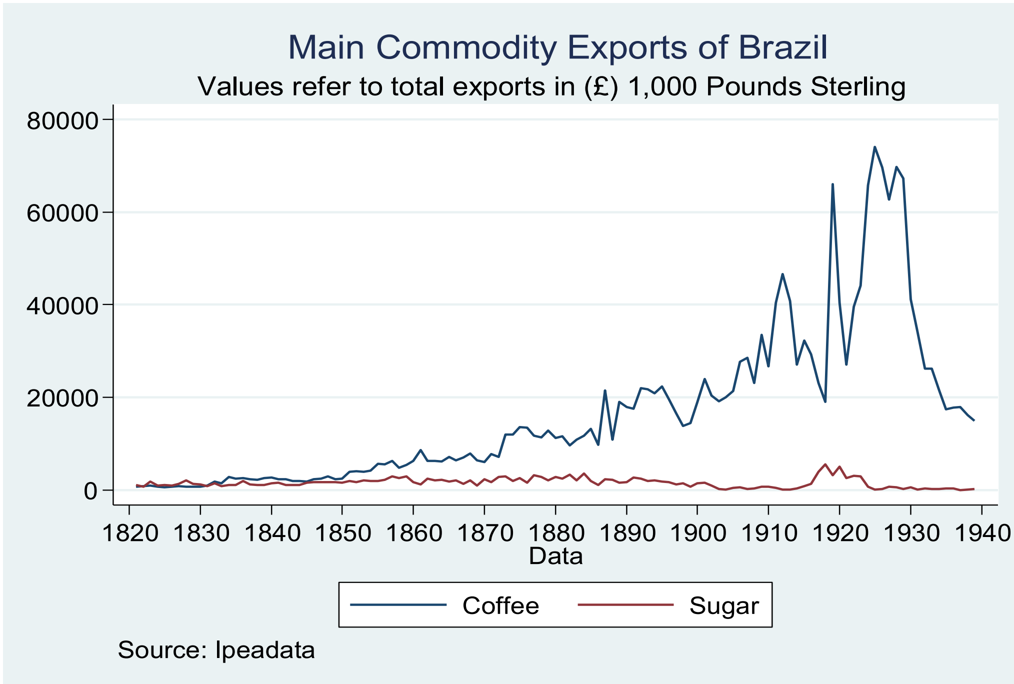
[17] Maria Graham, *Journal of a Voyage to Brazil: And Residence There During Part of Years: 1821, 1822, 1823* (London: Longman, Hurst, Rees, Orme, Brown, and Green, 1824).

[18] Bahia D. E. Borges, *The Family in Bahia, Brazil, 1870-1945.* (Stanford, CA: Stanford University Press, 1992).

[19] Ian Read, "Brazil's Era of Epidemics: How Disease Shaped a Nation," in *Tropical Wellbeing: Perspectives on Public Health in Brazilian History* (BRASA XIII, Brown University, Providence, RI, 2016).

[20] Sources of original data vary; all figures collected from www.ipeadata.gov.br

Figure 1.1



From the figure, one can see that sugar and coffee were relatively equal in the value exported until 1850, when the total value of coffee exports began trending upwards until the market crash associated with the Great Depression in the 1930s. After 1850, the value of sugar exports stagnated until the mid-1880s, when a noticeable decline in exports began that lasted until the onset of WWI. While there was a post-war boom in sugar prices worldwide, this period came to an abrupt end in the early 1920s. The resounding importance of the coffee sector would be seen throughout the nineteenth and early-twentieth centuries. From 1890 to 1940, Brazilian coffee accounted for over 60 percent of global production. More specifically, during the 1900-1930 interval, Brazilian production represented over 70 percent of world production. This tremendous share in global production implied that Brazil remained a price setter in the world market, at least prior to the onset of competition from Colombian, Central American, and African coffee in the mid-twentieth century. Brazil's comparative advantage in coffee is one factor that sets it apart from other Latin American nations during the agro-export boom that began in the late-nineteenth century.

With the transition of Brazil's comparative advantage from sugar to coffee, industrial development soon followed. Scholars recognize the year of 1870 as the starting point of the country's first industrial surge.[21] According to Warren Dean, coffee production initially provided a stimulus for industrial development by creating a money economy, providing sufficient capital accumulation for rudimentary manufacturing to take flight.[22] Wilson Cano indicates that several components of the "*Paulista* coffee complex" acted synergistically to establish the prerequisites for industrial expansion. On the one hand, the coffee sector spurred increased production in foodstuffs and raw materials, and it generated industrial offshoots related to coffee production, such as the manufacture of burlap sacks and other packaging materials. On the other hand, coffee production stimulated railroad construction and other infrastructural improvements, as well as the expansion of the banking system.[23] Coupled with increased immigration from abroad, these factors converted São Paulo into Brazil's industrial powerhouse. Despite the dominance of *Paulista* industry, other states in the South and Southeast also enjoyed a high degree of industrial development. To provide a sense of the regional concentration of industry in the early-twentieth century, Figure 1.2 displays the number of industrial establishments by state in 1907.[24] The fact that industrial production was centered in the

[21] Leff, *Underdevelopment and Development in Brazil: Vol. 1 Economic Structure and Change, 1822-1947.*

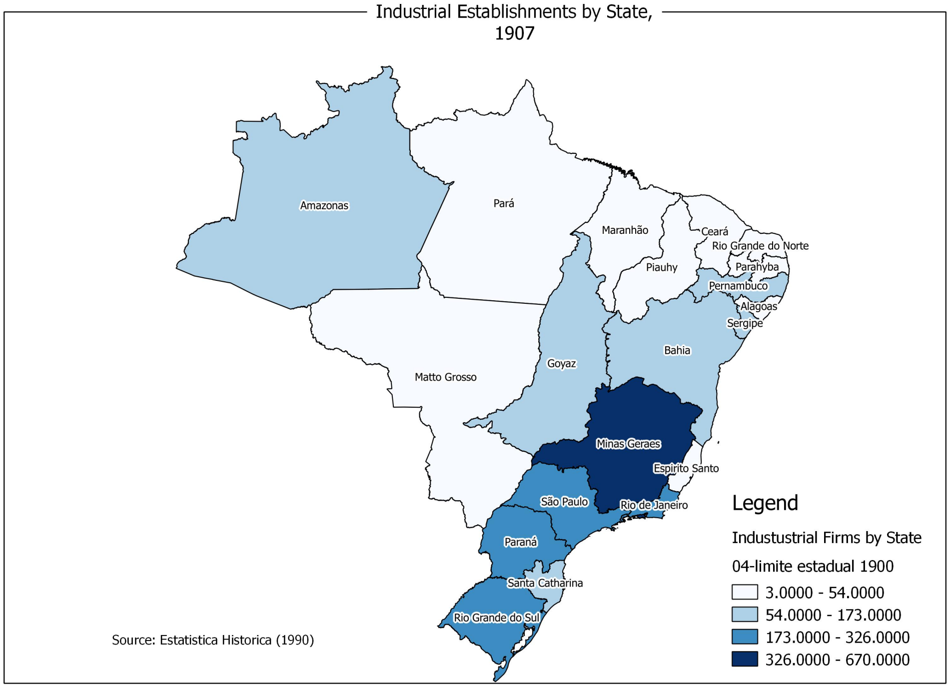
[22] Warren Dean, *Industrialization of São Paulo, 1800-1945* (Austin: University of Texas Press, 1970).

[23] Wilson Cano, *Raízes Da Concentração Industrial Em São Paulo.* (São Paulo: Difel, 1977).

[24] IBGE Brasil, *Estatísticas Históricas Do Brasil: Séries Econômicas, Demográficas E Sociais de 1550 a 1988.*, 2a ed. (Rio de Janeiro: IBGE, 1990), 382.

Southeast, particularly in the states of Minas Gerais, Rio de Janeiro, and São Paulo, is readily observable.

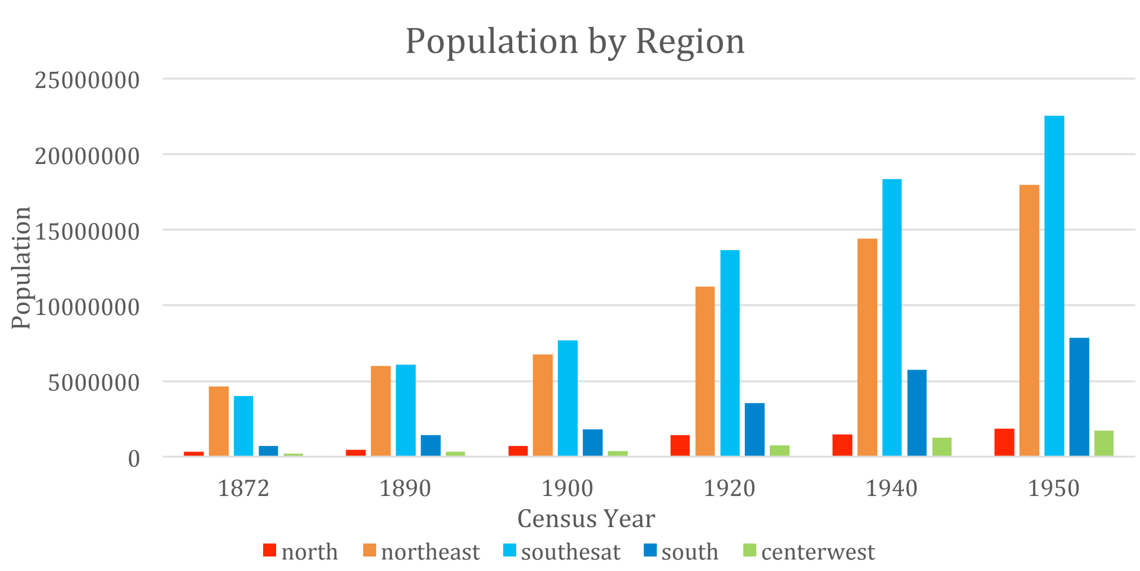
Figure 1.2



With the burgeoning coffee economy and nascent industrial sector centered in Brazil's Southeast, Brazil also saw a marked shift in regional demographic concentration over the nineteenth and early-twentieth centuries. Figure 1.3 plots regional demographic trends from the censuses of 1872 through 1950. As measured by Brazil's first official census in 1872, near the beginning of our study period, 46.7 percent of the country's 9.9 million persons resided in the Northeast and 40.5 percent in the Southeast. In that same year, the South accounted for only 7.3 percent of the total population, and the North and Center West for 3.4 percent and 2.2 percent, respectively. The Southeast and the

Northeast were roughly on par in terms of population share in 1890, with both accounting for approximately 42 percent of the total population. As national migrants and international immigrants arrived in the late-nineteenth century, the Southeast gained in importance. As enumerated in the 1900 census, 44.5 percent of the population now resided in the Southeast, while only 39 percent resided in the Northeast. In 1920, the Southeast represented 44.6 percent of the 30.6 million total population, while the Northeast accounted for only 36.7 percent.

Figure 1.3



Source: *Estatísticas históricas do Brasil*. 1990.

We can note that a miniscule fraction of the population resided in the North and Center-West throughout the period. Throughout the censuses spanned by the period studied here, the North accounted for between 3.35 and 4.69 percent of the total population, while the Center-West accounted for between 2.25 and 3.34 percent. This is of little surprise since both were frontier regions for much of the period. The apex of the North's population share was reached in 1920, two decades after international rubber prices reached their highest values in the 1900s (see Table 1.4 in the Appendix to this chapter).[25] In addition to commodity specializations across states, due to the differences in the disease environment prevailing in disparate regions, understanding the regional shift in demographic concentration will be important for the discussion of average height over time in Chapter 4.

Concomitant with the country's industrialization, Brazil embarked on a path of gradual emancipation with the implementation of the Rio Branco law in 1871 (also known as the Law of the Free Womb), which stated that all children of slave mothers were to be born free. As the agricultural elite became concerned with the possibility of labor shortages, state officials developed policies to promote European immigration to Brazil. In the late-nineteenth century, certain intellectuals subscribed to the philosophy that a process of *branqueamento* (whitening) would aid Brazil in her quest for modernity, and coffee-producing states like São Paulo began to subsidize immigration (primarily from Italy). In addition to the racist foundation behind such policies, the emphasis on immigration had the unfortunate outcome of preventing a more complete transfer of the factors of production (namely labor) from the waning sugar-producing Northeast to the area of Brazil's newfound comparative advantage, the Southeast coffee belt.[26] Unsubsidized immigration from other European nations surged in the 1890s and remained an important contributor to total population growth for much of the early-twentieth century.

[25] IBGE Brasil, *Séries Estatísticas Retrospectivas: Repertório Estatístico Do Brasil--Quadros Retrospectivos (Separata Do Anuário Estatístico Do Brasil—Ano V—1939/1940)*, vol. 1 (Rio de Janeiro: Serviço Gráfico do IBGE, 1941).

[26] Leff, *Underdevelopment and Development in Brazil: Vol. 1 Economic Structure and Change, 1822-1947.*

Table 1.1 presents statistics on the inflow of immigrants to Brazil by sending country in specific intervals from 1884 through 1939.[27] The nations that sent immigrants to Brazil in greatest abundance were Italy, Portugal, Spain, and Japan (although immigration from Japan did not commence until 1904). In addition, a large number of immigrants came to Brazil from Germany, Russia, Austria, the Ottoman Empire/Turkey, and Poland. As we shall see in Chapter 4, since the wave of international migration coincides with the period height increase, my analysis must distinguish any potential positive effects on stature emanating from the immigrant population from that of the Brazilian-born, an obstacle I tackle by isolating uncommon surnames of soldiers.

Table 1.1

Inflow of Immigrants to Brazil by Sending Country, 1884-1939

	1884-1893	**1894-1903**	**1904-1913**	**1914-1923**	**1924-1933**	**1934-1939**	**TOTAL**
Italian	510533	337784	196521	86320	79177	10928	1412263
Portuguese	170621	157542	384672	201252	233650	56657	1204394
Spanish	103116	102142	224672	94779	52405	4604	581718
Japanese	.	.	11868	20398	110191	43342	185799
German	22778	6698	33859	29339	61728	16243	170645
Russia	40589	2886	48100	8096	7953	497	108121
Austrian	13684	32456	22961	6285	8814	1680	85790
Turkish	3	6522	42177	19255	10227	271	78455
Polish	370	1059	.	3073	33957	9315	47765
Rumanian	.	.	248	4396	33404	1065	39113
Others[28]	21963	15030	41601	30788	112717	20682	244654
Total	883668	852110	1006617	503981	737223	165663	4158717

Source: IBGE, *Quadros retrospectivos*, 1941, 17.

[27] Brasil, *Séries Estatísticas Retrospectivas: Repertório Estatístico Do Brasil--Quadros Retrospectivos (Separata Do Anuário Estatístico Do Brasil—Ano V—1939/1940)*.

[28] Others include French, Lithuanian, English, Yugoslav, Syrian, Argentine, American, Swiss, Uruguayan, Hungarian, Dutch, Belgian, and Swedish immigrants.

The Importance of the First Republic

After a military coup, democratic governance came to Brazil in 1889 with the emergence of the First Republic (1889-1930). The advent of the Republican state constituted a watershed moment in the country's timeline. In the late-nineteenth century, social thinkers and policymakers engaged in fervent debates regarding the best way to transform Brazil into a 'modern' nation. In the field of economic history, recent research has pointed to the improvements in the provision of public goods consequent of the transition to republican governance in 1889. Quantitative work on the era has chiefly responded to structuralist economic history researchers who assumed that state intervention in the economy was largely absent until the emergence of Getúlio Vargas' populist government in 1930.[29] According to Nathaniel Leff's seminal reference of economic development in Brazil in the nineteenth and twentieth centuries, the First Republic implied a vast decentralization of government spending. The Constitution of 1891 allowed for states to tax their own exports, and this fomented the creation of modern institutions.[30]

As noted previously, information asymmetries had long curtailed investment in Colonial and Imperial Brazil, and the Republican state eased constraints to economic development by improving financial regulations, fostering depersonalized lending institutions, and creating bond and equity markets like the São Paulo Stock Exchange. Modern financial institutions removed the information asymmetries that distorted

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[29] For a prime example, see Peter B. Evans, *Dependent Development: The Alliance of Multinational, State, and Local Capital in Brazil* (Princeton: Princeton University Press, 1979).

[30] Leff, *Underdevelopment and Development in Brazil: Vol. 1 Economic Structure and Change, 1822-1947.*

incentives and discouraged investment.[31] While the advent of railroads in Brazil dates back to the 1850s, the rate of construction greatly increased in the 1890s thanks to subsidies provided by the First Republican government, and railroads augmented both agricultural and industrial productivity. While foreign investment for railroad construction was an important factor, one must keep in mind that the government played a large role in securing dividends for investors, and by 1889 the state owned 34 percent of the total extension of track. The emergence of the railroad network in Brazil had the benefit of increasing prices to producers and decreasing those faced by consumers. This increased profits for reinvestment, bolstered output, and enhanced labor productivity and mobility.[32] Scholars have found that state-level export taxation was positively correlated with public investment in key areas of human capital formation like primary education.[33] The role of financial regulations and increased investment in hard infrastructure and education have received ample attention from quantitative historians, yet gaps in our knowledge remain regarding the health outcomes of policy changes associated with the First Republican era. This dissertation mends this gap by discussing the impact of innovations in social and sanitary policy on heights.

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[31] Gail D. Triner, *Banking and Economic Development: Brazil, 1889-1930.* (New York: Palgrave, 2000); A. Hanley, *Native Capital: Financial Institutions and Economic Development in São Paulo, Brazil, 1850-1920.* (Palo Alto, CA: Stanford University Press, 2005).

[32] William R. Summerhill, *Order Against Progress: Government, Foreign Investment and Railroads in Brazil, 1854-1913.* (Palo Alto, CA: Stanford University Press, 2003).

[33] Aldo Musacchio, A. M. Fritscher, and Martina Viarengo, "Colonial Institutions, Trade Shocks, and the Diffusion of Elementary Education in Brazil, 1889-1930.," *The Journal of Economic History* 74, no. 03 (September 2014): 730–66.

In addition to an increased degree of economic interventionism, the First Republic was also characterized by augmented state activism in public health and sanitation.[34]. One of the first legal actions of the Republican government that came to power in 1889 was the promulgation of a bill on public health and sanitation in 1891. The bill created centralized plans to modify prophylactic measures, sanitation codes, and medical care. Despite its incomplete implementation, historians have emphasized that the new public health and sanitation law marked a disjuncture with the haphazard and ad hoc methods of controlling disease that prevailed during the Empire.[35] In addition, the Criminal Code of 1890 criminalized the illegal practice of medicine for the first time in an effort to supplant traditional, 'folk' healing techniques with methods sanctioned by (European) medical orthodoxy.

State intervention in sanitation and hygiene occurred amid a larger backdrop of scientific advances in the Western world related to the germ theory of disease. Historians have highlighted key individuals that served as the interlocutors between international scientific currents and Brazilian public-health policy. In the late-nineteenth century in the newly-created Belo Horizonte, Saturnino de Brito, an innovator in national *engenharia sanitária* (or sanitary engineering), oversaw the construction of the first sewage system in Brazil that separated rainwaters from sewage waste (referred to as the *sistema de separador absoluto*, or the total separator system).[36] Oswaldo Cruz, who had trained in microbiology at the Pasteur Institute in Paris, headed research projects on the bubonic

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[34] Gilberto Hochman, *A Era Do Saneamento: As Bases Da Política de Saúde Pública No Brasil* (São Paulo: Editora Hucitec, 1995).

[35] Teresa A. Meade, *Civilizing Rio: Reform and Resistance in a Brazilian City, 1889-1930.* (University Park, PA: The Pennsylvania State University Press, 1997).

[36] Rezende and Heller, *O Saneamento No Brasil: Politicas E Interfaces*, 109–112.

plague and yellow fever in Rio de Janeiro at the *Instituto Soroterápico Federal de Manguinhos* (which later came to bear his name, the *Instituto Oswaldo Cruz*). Subsequently, Cruz became Director of Public Health and implemented numerous programs in public hygiene (such as the vaccine law and other health initiatives discussed in the introduction to this chapter).[37] By international standards, scientific inquiry in Brazil in this period was reasonably progressive. It was the Brazilian physician Emílio Ribas that definitively solidified the scientific knowledge on the mode of transmission of yellow fever in 1901, substantiating previous research by American scientists in Cuba that the *aedes aegypti* mosquito was the carrier, and proving that the disease was not transmitted via direct contagion from infected persons.[38] While the influence of these individuals' efforts on hygiene and sanitary policy reforms has received ample attention, extant scholarship fails to measure the efficacy of these trends in scientific development using actual health outcomes. Using anthropometric data, this dissertation seeks to make temporal links between improvements in health status of the Brazilian population and advances in sanitation and medicine.

Social historians have examined public health policy in the First Republic and Vargas eras. Much of the scholarship has focused on the Oswaldo Cruz health campaigns of the early-twentieth century. Others assume that conditions did not largely improve

[37] Nancy Stepan, *Beginnings of Brazilian Science: Oswaldo Cruz, Medical Research and Policy, 1890-1920* (New York: Science History Publications, 1976).

[38] John Allen Blount III, "The Public Health Movement in São Paulo, Brazil: A History of the Sanitary Service, 1892-1918." (PhD Dissertation, Tulane University, 1971), 115-116; Jaime Larry Benchimol, *Dos Micróbios Aos Mosquitos: Febre Amarela E a Revolução Pasteuriana No Brasil.* (Rio de Janeiro: Editora Fiocruz / Editora UFRJ, 1999), 410-12.

until the Vargas era.[39] Adamo reveals that the health campaigns of the early-twentieth century benefited the white population more than the population of African descent.[40] Otovo examines the *maternalista* (maternalist) movement in Brazil and demonstrates how international debates on health and progress melded with local desires to modernize the nation.[41] While these studies make ample contributions to Brazil's historiography, generally much of the scholarship related to public health history has lacked evidence on population health indicators to assess the outcomes of advances in social and public welfare policy.

The effects of World War I ushered in several macro-economic changes. Imports of industrial machinery to Brazil nearly ceased with the onset of the war in 1914. 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 laboring classes as a result of the inflationary spiral during WWI.[42] This erosion of purchasing power in the mid-1910s could have impacted the health of the population, particularly for urban dwellers more tied to the wage economy. In the face of soaring prices, the working class likely responded by

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39 André Luiz Vieira de Campos, *Políticas internacionais de saúde na Era Vargas : o Serviço Especial de Saúde Pública, 1942-1960* (Rio de Janeiro: Editora Fiocruz, 2006). See also Cristina M. Oliveira Fonseca, *Saúde no Governo Vargas (1930-1945): dualidade institucional de um bem público* (Rio de Janeiro: Editora Fiocruz, 2007).

40 Sam C. Adamo, "The Broken Promise: Race, Health, and Justice in Rio de Janeiro, 1890-1940." (PhD Diss. University of New Mexico, 1986).

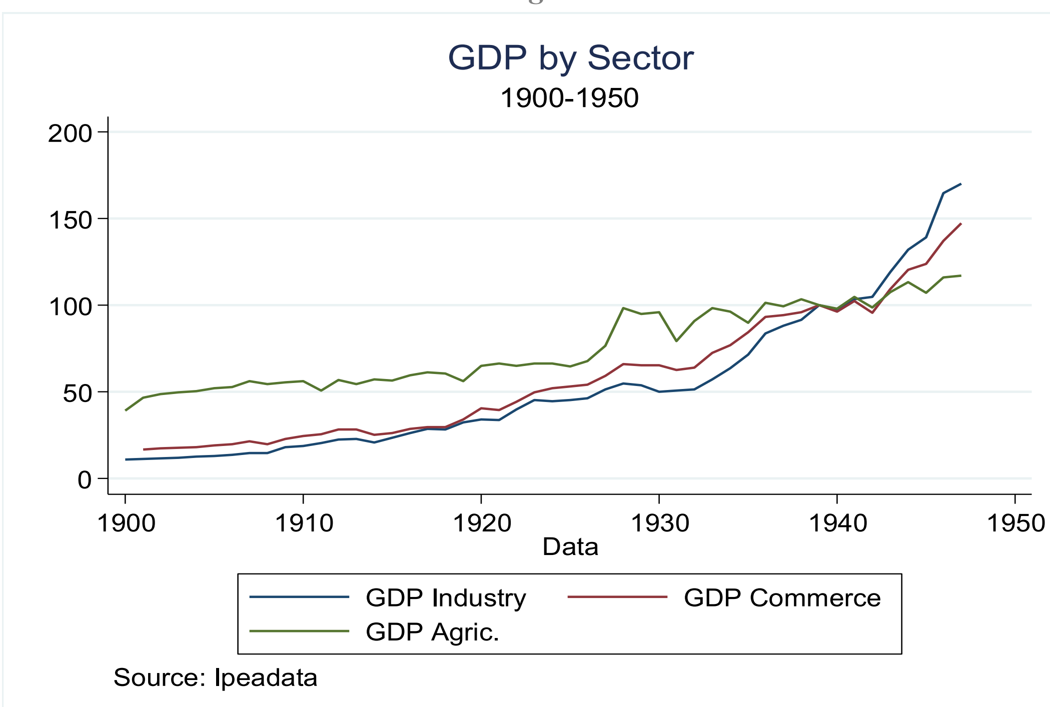
41 Okezi Otovo, "To Form a 'Strong and Populous Nation': Race, Motherhood, and the State in Republican Brazil" (PhD Dissertation, Georgetown University, 2009).

42 Molly C Ball, "Inequality in São Paulo's Old Republic: A Wage Perspective, 1891-1930." (PhD Dissertation, UCLA, 2013).

reducing nutritional intake altogether or by substituting away from more expensive protein sources in favor of less quality nutrients.

The 1920s in Brazil were a politically tumultuous period leading up to the Revolution of 1930, which propelled Getúlio Vargas to power. Vargas instituted a populist, authoritarian regime with a corporatist structure. The Great Depression of the 1930s brought a radical shift in Brazilian political economy, as the collapse of coffee prices on the world market illustrated the dangers of overdependence of monocrop export agriculture. The Depression provided the stimulus to diversify the Brazilian economy, giving rise to the era of import-substitution industrialization. During this period, Brazil entered into heavy industry. As we can see from Figure 1.4, by 1940 industrial GDP had already surpassed that of agriculture. The effect of these policies was rapid economic growth; from 1930-45, GDP per capita rose by an average of 4 percent per annum.[43]

Figure 1.4



[43] Luna and Klein, *The Economic and Social History of Brazil since 1889*, 106.

1.2 Inquiries into Health and Living Standards

Scholars have proposed a myriad of methods to examine historical trends in health and living standards. Among the indicators used by researchers to study population health in historical societies are measures of income and vital indicators taken from surveys or censuses. In studying Brazil's nineteenth and twentieth centuries, both income and demographic measures have been employed in the literature with differing degrees of success.

One widely-used technique to examine historical trends in economic welfare utilizes income per capita. When combined with data on the cost of living, or with some knowledge of changes in price levels, data on income per capita can provide a strong foundation for the study of living standards. The historical literature on Brazil contains several noteworthy studies on wage and price histories in the nineteenth and twentieth centuries. Previous work by historians to uncover trends in per-capita income has honed in on working-class wages with micro-level data from company and public pay registries. Eulália Maria Lahmeier Lobo and Katia de Queirós-Matoso conducted pioneering work in this field of study in the 1970s. Lobo focused on the city of Rio de Janeiro in the nineteenth and twentieth centuries, and her research established price and wage indices for the city between 1820 and 1930.[44] Queirós-Matoso collected data on food prices and wages in nineteenth-century Salvador, Bahia, and her research indicates an upward trend

[44] Eulalia M. L. Lobo, *História Do Rio de Janeiro (do Capital Comercial Ao Capital Industrial E Financeiro) V.2.* (Rio de Janeiro: IBMEC, 1978).

in both prices and wages beginning in the 1850s.[45] More recently, Molly Ball offers valuable insights on industrial wages and inequality amongst immigrants in early-twentieth-century São Paulo.[46] These efforts have helped shed light on general living conditions and wage inequality in the nineteenth and early-twentieth centuries; however, one drawback to the income approach is that the nature of the historical sources generally limits the scope of inquiry to particular areas. For example, while extant studies incorporating wage data of streetcar personnel or industrial workers in the city of Rio de Janeiro offer a glimpse into the standard of living in that city,[47] they provide no window into the quality of life of Brazilians engaged in subsistence agriculture in the interior of Minas Gerais.

Leading scholars in the field of economic history point to the limited explanatory power of income data in making generalizations about human welfare across regions and over time.[48] While studies such as Queirós-Motoso's, Lobo's, and Ball's have numerous virtues, their explanatory power in terms of national trends in health and living standards is limited. The same can be said regarding any study that makes inferences regarding health and living standards from wage data, since increased income does not necessarily dictate the orientation of household spending. Greater purchasing power does not always assure that individuals will make more health-augmenting investments, such as spending

45 Katia M de Queirós Matoso, *Bahia: A Cidade Do Salvador E Seu Mercado No Século XIX* (São Paulo, SP: HUCITEC, 1978).

46 Ball, "Inequality in São Paulo's Old Republic: A Wage Perspective, 1891-1930."

47 See Eileen Keremitsis, "The Early Industrial Worker in Rio de Janeiro, 1870-1930". (PhD diss., Columbia University, 1982). Also see, Maria A. Guzzo de Decca, *Indústria, trabalho e cotidiano: Brasil, 1880 a 1930* (Rio de Janeiro: Atual, 1991).

48 Robert W. Fogel, Stanley L. Engerman, and James Trussell. "Exploring the uses of data on height: The analysis of long-term trends in nutrition, labor welfare, and labor productivity." *Social Science History* (1982): 401-421.

more on nutritious food. In aggregate terms, an increase in income might signify little improvement in health if local governments provide insufficient sanitary services or if other confounding factors arise. For instance, the effect of extra income on health could be mitigated in the midst of a high degree of urban overcrowding brought on by immigration and rural-urban migration. In explaining the health transition in the United States, Dora Costa provides a clear summary regarding the intersection between income and health: "Income in the 19th century enabled individuals to buy lower room congestion, housing in an area of a city with better sanitation, private toilet facilities, soap, better food, and icebox to preserve food, and less work away from home for the pregnant mother."[49] If average incomes rose amid other mitigating factors, such as an increase in population living in crowded, ill-serviced residential buildings, the effect on a population's health status would be ambiguous. Given the isolated and fragmentary nature of income data, historians concerned with historical trends in health in Brazil must turn to other sources. Below, I discuss the extant inquiries on Brazil relying on demographic evidence.

Conventional Health Measures

Indicators inferred from vital statistics—such as crude mortality and infant mortality rates or estimates of life expectancy—constitute another avenue of inquiry into population health. General patterns in mortality, fertility, and population growth are a useful means of characterizing Brazil's demographic history. Merrick and Graham provide a detailed account of demographic trends over the nineteenth and twentieth centuries, decomposing the factors related to population growth. Table 1.2 displays components of population growth for the 1850-1970 interval. The highest rates of natural

[49] Costa, "Health and the Economy in the United States, from 1750 to the Present." 27.

increase are found in the 1951-60 period, although rates continuously inclined from 1840 onward. Aside from the latter-twentieth century period, the most rapid incline in the rate of natural increase took place between the 1840-70 (14.2) and 1871-90 (17.1) periods. While births per 1,000 population remained relatively high and stagnant until 1920, deaths per 1,000 population declined steadily in the late-nineteenth century, from 32.3 in 1840-70 to 26.4 at the dawn of the twentieth century. The mortality rate was halved by the 1961-70 period. It should be noted that the censuses from which these figures are derived, especially those prior to 1940, are subject to some inaccuracies.[50]

Table 1.2

Decomposition of Population Growth in Brazil, 1850-1970 All figures represent average annual rates per 1,000 population					
Period	Total Increase	Migration	Natural Increase	Births	Deaths
1840-70	15.2	1	14.2	46.5	32.3
1871-90	19.1	2	17.1	46.6	29.5
1891-1900	20.2	6	18.2	46	27.8
1901-20	21.2	2.2	18.6	45	26.4
1921-40	20.5	1.8	18.7	43.5	24.8
1941-50	23.8	0.4	23.4	44.4	20
1951-60	30	0.9	29.1	43.3	14.2
1961-70	27.9	0.1	27.8	40.8	13
Source: Merrick & Graham, *Population and Economic Development*, 37.					

In addition to general demographic trends, demographers and social scientists interested in health often rely on estimates of life expectancy at birth. Life expectancy in particular has fueled a number of path-breaking studies on the health consequences of institutional development. For example, Richard Easterlin has argued that long-term improvements in health and economic growth were only possible after genuine state

[50] Thomas W. Merrick and Douglas H Graham, *Population and Economic Development in Brazil: 1800 to the Present* (Baltimore and London: The Johns Hopkins University Press, 1979).

involvement in public-health institutions commenced.[51] Estimates of life expectancy for Brazil in the second half of the twentieth century can be made with ample precision, since the national censuses were more precise and taken at regularly spaced intervals. However, applying the direct methodology to Brazil in the nineteenth and early-twentieth centuries becomes more complex because of census inaccuracies, the underreporting of births, and low levels of numeracy—common features of pre- and early-industrial societies that particularly affected Brazilian censuses prior to the 1940 census. Throughout the twentieth century, social scientists have grappled with these issues in attempting to reconstruct Brazil's demographic history.

Table 1.3

Estimates of Life Expectancy at Birth				
Period	**Mortara**	**Arriaga**	**Carvalho**	**IBGE**
1870		27.3		
1880	33.9	27.6		
1890		27.8		
1900		29.4		
1910	39.3	30.6		
1920		32		
1930		34		
1940		36.7	41.2	
1950	43.7	43	43.6	
1960		55.5	49.6	52.3
1970			53.4	59.3
Source: Merrick and Graham, *Population and Economic Development*, 42.				

The extant estimates of life expectancy for Brazil during the late-nineteenth and early-twentieth centuries are conflictual (see Table 1.3). Mortara derived life expectancy estimates by comparing intercensal growth rates across the age distributions in the censuses. Arriaga applied stable population methods to infer life expectancy at birth

51 R. A. Easterlin, "How Beneficient Is the Market? A Look at the Modern History of Mortality," *European Review of Economic History* 3, no. 3 (December 1999): 257–94.

based on the age distributions within the censuses and model life tables. The stable population technique was then applied by other researchers. Although not completely discrepant, the differing estimates call into question their reliability. Both estimates composed by Mortara and Arriaga seem to converge at roughly the same value (43.7 and 43 years, respectively) in 1950; however, they differ substantially in the timing of the improvement, with Arriaga attributing more weight to the post-1930 period. Mortara calculated his estimates before an overcount of roughly 10 percent was discovered in the 1920 census. The inaccuracies in these earlier censuses were more pervasive amongst the lower age groups, and Arriaga based his estimates on ages 10-59 in order to overcome this issue.[52] Both sets of estimates denote upward trends that square well with other population parameters and general hypotheses about socio-economic development in the era, yet the differences in the methods used, and in which model life table to apply in the case of Arriaga, invite skepticism regarding the accuracy of the estimates. Determining which set of estimates is the most accurate will require much future study.

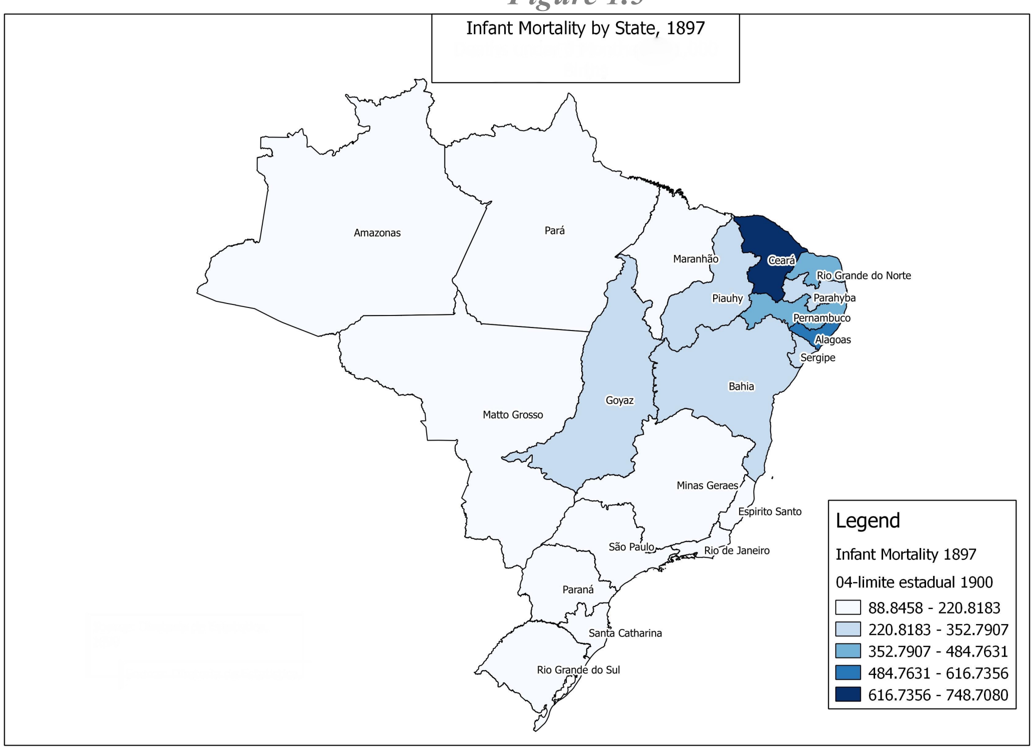
Similar margins of error in reporting call into question the validity of other welfare indicators drawn from census records such as infant mortality—commonly defined as the number of deaths under the age of 1 year relative to the total amount of live births. If recorded properly, infant mortality can be extremely useful for the examination of population health trends since the measure largely reflects hygienic and sanitary conditions. However, as noted in the discussion on life expectancy, the official monitoring of population statistics was inadequate in nineteenth- and early-twentieth-century Brazil. Similar to the limited geographic scope of real wages discussed above, in

[52] Merrick and Graham, *Population and Economic Development in Brazil: 1800 to the Present.*, 40-41.

Brazil prior to 1940 the most complete records on infant mortality apply to major urban areas.

The earliest official records with state-level infant mortality rates date back to the late-1890s. The scant records available for this period point to a large discrepancy in infant mortality rates between states, with the Northeast exhibiting the highest indices overall (see Figure 1.5).[53] It is unclear how accurate these figures are; however, the patterns fall in line with what we might expect based on other available evidence and general assumptions about regional development patterns. As such a vast territory in which administrative areas differed greatly in terms of population density and levels of literacy, we must question how accurately the Brazilian government was able to monitor trends in infant births and deaths in the late-nineteenth century.

Figure 1.5



53 Directoria Geral de Estatística Brasil, *Registro Civil, 1897* (Rio de Janeiro: Officina de Estatística, 1903), 200-01.

In addition, the city of Rio de Janeiro and the entire state of São Paulo appear to have maintained records on infant births and deaths of extraordinarily good quality for the period. One recently digitized source compiled by the Fundação SEADE provides the only reliable vital statistics for a complete state, retaining vital statistics for all of the municipalities in São Paulo State from 1894 through 2010.[54] At the city level, the Summary of Biostatistics reports infant mortality records from the 22 capital cities of Brazil from 1920 through the 1940s.[55] These city-level statistics appear to be reliable, but their power to explain health trends for the vast cross-section of the population is limited. The Brazilian territory was rather sparsely populated during the period studied here. In 1940, over 68 percent of the population resided in urban areas of less than 50,000 inhabitants.[56] As we shall see in Chapters 3 and 4, using data on stature has the benefit of observing health trends in rural areas.

In sum, the gaps in the available nineteenth- and early-twentieth-century documentation present major obstacles to the health historian of Brazil. The inadequate administrative capacity and poor civil accounting characteristic of the period, coupled with the population's limited numeracy and literacy and its dislocation from the monetary economy, complicate the use of conventional demographic indicators. The existing estimates of life expectancy for the period diverge substantially based on techniques used to overcome census enumeration errors, providing an inadequate understanding of the

[54] Fundação SEADE, Memória das Estatísticas Demográficas—http://produtos.seade.gov.br/produtos/500anos/

[55] US Department of Commerce, *Brazil, Summary of Biostatistics: Maps and Charts, Population, Natality, and Mortality Statistics* (Washington DC: Bureau of the Census, 1948).

[56] Author's own calculations for share of population by city size, derived from www.ipeadata.gov.br.

health status of the Brazilian population. What is more, the censuses of Brazil do not contain population-by-age statistics disaggregated at the state or regional levels prior to the 1950 census, thus precluding an examination of regional differentials in health status.

1.3 Conclusion

This chapter has provided an historical overview of the 1850-1950 period in Brazil. I discuss the emergence of the First Republic as a watershed moment in the country's timeline. We have seen that Brazil's Imperial period saw little economic growth, as the performance of the sugar economy began to wane in the face of production from the West Indies over the nineteenth century. Further, the endurance of the institution of slavery until 1888 hemmed down social mobility and provided a disincentive for immigrants to settle in Brazil. Indications of economic progress were seen with the emergence of the burgeoning coffee export sector over the course of the nineteenth century, as well as the country's first industrial surge which began circa 1870. With the advent of a market economy centered in the Southeast, there was also a significant transition in population concentration from the Northeast to the Southeast. The First Republic implied a radical increase in government spending in key areas that foment economic growth: financial regulations, education, hard infrastructure, and public health. All of these factors served to intensify the rate of economic growth that had begun before the First Republic.

Despite this interpretation of the First Republic, not all historians view the period with a sanguine eye. Economic historians working in the dependency theory tradition have tended to view the First Republic as a failed experiment that had limited success in engendering improvements in the standard of living and long-term economic growth. Still others, although not explicitly part of the same conceptual framework, are inclined to interpret advances in sanitation in the same negative light. The rhetoric of dependency theory has permeated numerous aspects of the historical literature. Based on the evidence presented in this dissertation, I call not for an outright revision of this interpretation, but rather for qualifications to existing assertions.

In the formative years of the discipline of historical anthropometrics, prominent economic historians Fogel, Engerman and Trussel sustained that anthropometric studies are "more representative of national trends than are long-term wage indexes compromised of narrow, discontinuous series."[57] Given the gaps in our knowledge discussed above, how then can we examine historical trends in health and living standards in nineteenth- and early-twentieth-century Brazil? To answer that question, my discussion will now shift to the theoretical basis of research in historical anthropometrics.

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[57] R. W. Fogel, S. L. Engerman, and J. Trussel, "Exploring the Uses of Data on Height: The Analysis of Long-Term Trends in Nutrition, Labor Welfare, and Labor Productivity.," *Social Science History*, 1982, 401–21, 407.

Appendix

Table 1.4 below reports information on the 8 principal commodities exported from Brazil from 1820 through 1939. The average decadal price of each export commodity (given in British pounds sterling per ton) figures in Panel A, while the share of each commodity in total exports appears in Panel B. Following conventions in the censuses, the retrospective tables issued by the IBGE list coffee prices per 60kg sack. I have computed the average per ton by multiplying the listed sack price by the number of sacks in 1 metric ton (1000kg/60kg/sack=16.667sacks). While Holloway sustains that coffee exports superseded those of sugar in the 1840s, data from the IBGE indicate that coffee displaced sugar as the main commodity exported from Brazil in the 1831.[59]

[59] Holloway, 1975: 160, cited by W. Baer, *The Brazilian Economy: Growth and Development.*, 7th ed. (Boulder, CO: Lynne Rienner Publishers., 2014).

Table 1.4

Foreign Exports from Brazil								
Panel A. Prices of Principal Commodities Exported								
Decade	**Coffee**	**Sugar**	**Cocoa**	**Mate**	**Tobacco**	**Cotton**	**Rubber**	**Leather**
1820								
1830								
1840								
1850	28.6	18.03	29.85	23.01	34.12	45.38	113.52	45.27
1860	36.69	16.62	41.67	18.86	37.46	98.22	129.45	42.55
1870	47.71	13.97	48.37	20.38	39.81	46.9	183.05	46.43
1880	44.31	11.17	50.48	15.2	30.34	40.79	150.57	38.71
1890	43.27	12.86	39.56	14.12	26.73	47.36	192.82	28.67
1900	27.59	9.96	54.12	26.17	43.56	52.02	344.45	59.56
1910	44.7	21.54	54.38	29.94	59.97	99.71	286.26	86.66
1920	61.84	18.6	42.4	25.82	52.78	109.68	103.06	70.88
1930	23.76	5.28	16.16	12.17	22.01	37.68	33.28	33.34
Panel B. Share of Principal Commodities in Total Exports								
1820	18.4	30.1	0.5	.	2.5	20.6	0.1	13.6
1830	43.8	24	0.6	0.5	1.9	10.8	0.3	7.9
1840	41.4	26.7	1	0.9	1.8	7.5	0.4	8.5
1850	48.8	21.2	1	1.6	2.6	6.2	2.3	7.2
1860	45.5	12.3	0.9	1.2	3	18.3	3.1	6
1870	56.6	11.8	1.2	1.5	3.4	9.5	5.5	5.6
1880	61.5	9.9	1.6	1.2	2.7	4.2	8	3.2
1890	64.5	6	1.5	1.3	2.2	2.7	15	2.4
1900	51.3	1.2	2.8	2.9	2.4	2.1	28.2	4.3
1910	53	3	3.6	3	2.6	2	12.1	6.2
1920	69.6	1.4	3.2	2.7	2.1	2.4	2.6	4.6
1930	52.4	0.4	4.1	1.7	1.6	13.9	1	4.4
Avg.	55.91	7.46	2.21	1.9	2.51	6.81	8.64	4.87

Source: IBGE Brasil, *Quadros retrospectivos*, 87-8.
Note: All figures are listed in British Pounds Sterling Per Ton

Chapter 2. Measuring Living Standards: Heights and their Determinants

Introduction

In 1911, the medical physician Arthur Lobo da Silva published an influential article on the physical characteristics of Brazilian soldiers, “Typo physico do soldado nacional” (The Physical Form of the National Soldier). In his publication, Lobo da Silva highlights the role that ethnicity was assumed to play in the observed regional variance in heights found throughout Brazil. Da Silva states:

> The Germans and the Poles that immigrate to the Southern states of our country and there intermix with naturals from the region will always take on a different physical form than that of São Paulo, for example, with the intermixing of the Italians, or in Rio de Janeiro with the intervention of the Portuguese, or in the Northern states where immigration is almost null and therefore the impact of external influences on ethnic formation is of little importance.[60]

While da Silva aptly describes the differences in physical size amongst the nations that sent immigrants to Brazil in abundance in the first decades of the twentieth century, the implication that racial or ethnic origin determined physical characteristics illustrates the faulty reasoning regarding heredity that was prevalent in the early-twentieth century.[61] In Brazil in the 1920s, policymakers that subscribed to the international eugenics movement adopted a Lamarckian view of heredity, assuming that traits such as feeblemindedness or proclivity to crime were the product of some genetic predisposition. Brazilian eugenicists

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[60] Arthur Lobo da Silva, “Typo Physico Do Soldado Nacional,” cited in "Anthropologia no Exército Brasileiro" *Archivos Do Museu Nacional* 30, 1928: 3-43; 11.

[61] Coincidentally, Lobo da Silva was right to point out that the patterns of settlement amongst the immigrant groups in Brazil would affect the population’s regional patterns in height, an issue that our discussion will return to in Chapter 6. However, Lobo da Silva erred in assuming that genetic composition explained differences in height amongst sending groups. Below, we shall see that height differentials among the sending European nations depended on their antecedent levels of human capital; i.e., the extent to which nutrition was adequate and respective local governments had invested in health and social welfare policies.

of the time blamed predetermined racial characteristics for the pervasiveness of crime amongst the lower classes, and the ethos of the era also held that the prevalence of disease amongst the Brazilian poor was attributed to racial factors, rather than to socio-hygienic conditions.

Although the eugenics movement fell out of vogue after the world witnessed the atrocities of Nazi racial hygiene, the role of heredity in shaping anthropometric measures such as height remained unclear until the late-twentieth century. It was not until the 1970s that Eveleth and Tanner published *Worldwide Variation in Human Growth*, their seminal reference on auxology, and provided empirical evidence to debunk the prevalent assumption that genetic make-up alone determined the size and shape of the human body. Establishing adult height as a reflection of one's nutritional status over the growing years opened up avenues of inquiry that had long been of interest to economic historians and other social-science researchers. The research emanating from the historical heights methodology has offered path-breaking insights on the economic and social history of Europe and the United States, as well as the history of American slavery, to provide a few examples. Applying the methods of anthropometric history to Brazil, this dissertation is the first geographically-comprehensive, long-run, and quantitative study on the country's health trends in the nineteenth and twentieth centuries.

In general terms, this chapter highlights the theoretical considerations that lie at the foundation of research in historical anthropometrics. Providing the reader with an adequate understanding of the factors that affect the human growth profile will be useful for the subsequent discussion of long-term height trends in Chapters 4 through 7. The discussion below is divided into four sections. First, Section 2.1 highlights the history of human growth studies from the early stages of the field until the inception of historical heights research in the economics literature. Next, Section 2.2 details the factors that determine terminal adult stature. Then, Section 2.3 surveys important anthropometric studies worldwide, while 2.4 assesses the extant historical heights studies on Brazil. Finally, Section 2.5 concludes.

2.1 On the Growth of Human Growth Studies

Since antiquity, observers have attached some cultural importance to tall stature, even prior to understanding the forces at play in determining human body size. It was not until the modern era, however, that scientific inquiry directly tackled biological questions of human growth. In the early-nineteenth century, political elites began to employ human growth studies for purposes of social control or humanitarianism. Early studies focused on the heights of children employed in factories in England, and from these lines of inquiry emerged the field that Tanner refers to as "auxological epidemiology, the use of growth data to search out, and later to define, sub-optimal conditions of health."[63] Among the first to note the socioeconomic correlates of variation in heights was the French physician Louis-René Villermé, who conducted a study on the heights of conscripts of the Napoleonic Army (1814-15) and found that height varied by region and wealth. Some early studies on human growth found their motivation in social control. For example, a compatriot of Villermé, François Chaussier, inaugurated a system to measure the heights of newborns in order to more surely arraign postpartum females accused of committing infanticide in Paris. In England, the institution attributed with the oldest data on

[63] J. M. Tanner, *A History of the Study of Human Growth* (Cambridge and New York: Cambridge University Press, 1981), 142.

children's heights known to researchers, The Marine Society, recorded the stature of the boys it recruited in order to better identify and punish deserters. [64]

While some of these early growth studies attempted to establish a link between particular anthropometric measures and proclivity to crime, other human growth inquiries were more altruistic. In 1833, Edwin Chadwick, an English lawyer and public health activist concerned with the health of Great Britain's industrial class, advocated for the measurement of all the children working in London factories. Later, in 1870 Francis Galton began a tradition of measuring all the school children of London.[65] Tanner summarizes the relationship between early human growth studies and the rise of the public-health movement in nineteenth-century Europe: "From the time of Villermé, returned from the horrors of the war in Spain, to the last report of the British Association Anthropometric Committee in 1883, heights and weights of children were measured primarily to provide ammunition in the continual battle for social reform."[66] Although these early human growth studies offered the first insights regarding the causes of reduced stature within a particular population, another century would pass until differences between populations were adequately understood.

The most significant scientific development regarding cross-population patterns emerged in the late-twentieth century. In the 1960s, the Human Adaptability section of the International Biological Programme (1964-74) commenced a massive study on the growth of children and adolescents around the globe. Eveleth and Tanner based their

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[64] Ibid. 396.

[65] It is worth noting here that Galton was the originator of the term "regression to the means." Based mainly on human height data, Galton's research paved the way for the development of more sophisticated statistical procedures that will be used in this dissertation.

[66] Tanner, *A History of the Study of Human Growth*. 397.

1976 publication, *Worldwide Variation in Human Growth*, on the data collected under the Human Adaptability project, analyzing the results from 340 projects in 42 countries. *Worldwide Variation* used a multitude of variables to examine the covariates of the human growth profile, many of which were derived from country- or region-level statistics. In sum, Eveleth and Tanner found that children from wealthy families grew much faster and taller than those from disadvantaged upbringings. They discovered that Africans from well-off regions (for example, the Yoruba of Nigeria) grew in patterns comparable to Europeans. Indo-Mediterranean children followed growth trajectories similar to those observed amongst Europeans and Africans. This ground-breaking study established that malnutrition and poor health were the root causes of low growth profiles.[67]

Eveleth and Tanner sustained that genetics were of little importance in determining stature at the population level. However, the authors note that one caveat applies, since Asiatic populations and their descendants in the Americas were found to be shorter than Europeans and Africans, even under the best conditions. While this finding poses some obstacles for studying the evolution of heights in Brazil, especially when it comes to analyzing individuals of Amerindian ancestry, we shall see in Chapter 4 that statistical analyses controlling for ethnicity aid in neutralizing any potential bias that may affect estimates of height.

[67] Phyllis B. Eveleth and James Mourilyan Tanner. *Worldwide Variation in Human Growth*. (New York: Cambridge University Press, 1976), 273.

2.2 Determinants of Human Height

Research by anthropometricians has served to dispel the commonly-held notion that body size is exclusively determined by genotype. To be sure, as noted by Eveleth and Tanner, particular genotypes appear to yield reduced stature in average terms, even under optimal socio-economic conditions. However, in cross-sectional studies, anthropometric research has established that genes determine at most 80 percent of one's terminal height.[68] The remaining 20 percent reflect nutritional status, or per the term coined by John Komlos, the biological standard of living. Nutritional status is an expression of energy consumed and expended—one's cumulative nutritional intake, minus the claims to those nutrients made by physical exertion, homeostasis, and the defense of infections. The human body requires nutrition in order to generate new cells for growth, to maintain metabolic integrity, and to sustain normal body functions. One's terminal height, then, should be understood as the cumulative sum of this energy balance throughout the growing years.[69]

Energy requirements of the body are considerably higher at times of significant growth; however, even when an individual is sleeping, there is a constant need for nutrition in normal cell proliferation. The body consistently utilizes energy for protein synthesis and the absorption of key micronutrients in digestion. Insufficient nutritional status impacts heights directly by limiting physical growth and indirectly by curtailing

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[68] Yurii S. Aulchenko et al., "Predicting Human Height by Victorian and Genomic Methods," *European Journal of Human Genetics*, no. 17 (2009): 1070–75.

[69] Floud et al., *The Changing Body: Health, Nutrition, and Human Development in the Western World since 1700.* Ch. 1.

immune defense functions, making the undernourished more susceptible to infection.[70] Provided this cursory overview of the determinants of heights, it is important to keep in mind that insufficient nutrition impacts adult height to differing degrees at different ages.

Although one's terminal adult stature is the cumulative sum of gains in height over the growing years, nutritional deficiencies are most detrimental to final height during the periods of the greatest increase in height, or the greatest velocity of growth.[71] Thus, the crucial periods influencing terminal adult height are the intrauterine, infant (before age 3), and adolescent stages of human growth.[72] On average, a child with proper nutrition and health will grow by about 45cm in the first three years of life, making this the period of greatest velocity in stature growth overall.[73] Tanner reveals that an individual's height at age 3 has a correlation coefficient with terminal stature of 0.8.[74] Given such rapid growth in the first 3 years of life, any insult to growth during this period will likely yield a large reduction in height in absolute terms.[75] Chronic illness and undernutrition before age 3 stunt growth, causing individuals to reach a diminished

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[70] David A. Bender, *Nutrition: A Very Short Introduction* (Oxford: Oxford University Press, 2014). Ch. 3 & Ch. 6.

[71] Anthropometricians sustain that an individual tends to reach adult height in the late-teen years in well-nourished populations. However, there is evidence to suggest that historical populations did not reach full height until the age of roughly 23. It is pertinent to note here that after the age of 50, individuals tend to decrease in stature due to postural loss. Therefore, the most appropriate ages to include in a heights series are from roughly 20-50.

[72] Floud et al., *The Changing Body: Health, Nutrition, and Human Development in the Western World since 1700.*

[73] Alexander Moradi, G. Austin, and J Baten, "Heights and Development in a Cash-Crop Colony: Living Standards in Ghana, 1870-1980." (Working Paper, 2013).

[74] J M Tanner, *Foetus into Man: Physical Growth from Conception to Maturity* (Cambridge, MA: Harvard University Press, 1978).

[75] Moradi, Austin, and Baten, "Heights and Development in a Cash-Crop Colony: Living Standards in Ghana, 1870-1980."

terminal height or to reach full adult height later in life. There is some debate regarding the body's ability to catch-up to normal levels following insults to growth in the early years of life; however, most researchers agree that an individual will not likely regain from any growth deficits experienced in the early ages, when normal growth in height is at its highest velocity.

Having a general understanding of nutritional status, we can now scrutinize specific determinants for further elucidation on how applying the historical heights methodology will yield important insights into Brazil's history. Adapted from Richard Steckel, "Stature and the Standard of Living," the schema appearing in Figure 2.1 lists factors affecting terminal adult stature, common sources of data on heights, and the consequences linked to changes in height.[76]

Figure 2.1

Socioeconomic Determinants

- Income
- Inequality
- Public Health
- Hygiene
- Disease Environment
- Technology
- Labor Organization
- Cultural Values
- Food Prices

Proximate Determinants

- Diet
- Disease
- Work Expenditure
- Maintenance
- Genes
- Climate

Stature

- Sources:
- Military
- Manifests
- Oath Takers
- Students
- Passports
- Convicts
- Police
- Regristration of Free Negroes
- National Guard
- Firemen
- Voter Registration

Functional Consequences

- Mortality
- Morbidity
- Work Intensity
- Labor Productivity
- Human Capital Formation
- Cognitive Development
- Personality

[76] Richard Steckel, "Stature and the Standard of Living," *Journal of Economic Literature* 33, no. 4 (1995): 1903–40, 1908.

While of little importance at the population level, the most immediate determinants of individual heights are genetics. However, as discussed above, height is at most 80 percent heritable. In terms of elucidating trends in population health, our interests lie in the factors that make up the remaining 20 percent of adult height (as discussed below).

Maternal Health and the Intrauterine Environment

Insults to physical development suffered *in utero* can have lasting effects on heights and health conditions in adulthood. Studies have indicated that low birthweight babies frequently fail to reach their full growth potential. In addition to restricting growth in the womb, low birthweight and small-for-gestational age babies have been linked to higher risk of developing non-communicable diseases, such as diabetes and hypertension, later in life.[77] Studies have also found that psychological stress has adverse effects on birth outcomes and can limit linear growth of the fetus by decreasing the amount of human growth hormone secreted by the mother.[78] These will be important considerations to bear in mind when we discuss the potential influence of physically-demanding labor during pregnancy in Brazil.

Nutrition and Heights

The quality of diet is of tremendous importance since it comprises the energy consumption used for growth. Both the total caloric value of foods consumed as well as their richness in micronutrients have a bearing on human heights. Overall, caloric intake is a major factor in energy stores used for physical growth; when total caloric intake is

[77] D J Barker, "The Fetal and Infant Origins of Adult Disease," *British Medical Journal* 301, no. 6761 (November 1990): 1111.

[78] Martin Foureaux Koppensteiner and Marco Manacorda, "The Effect of Violence on Birth Outcomes: Evidence from Homicides in Rural Brazil," *IDB Working Paper Series* IDB-WP-416 (2013).

insufficient, the body responds by curtailing growth. However, purely assessing nutritional intake on total caloric consumption would be incomplete, since the quantity and quality of protein intake also has a significant influence on physical development. Other nutrients that have an influence on growth are the essential amino acids, iron, calcium, and zinc, as well as Vitamins A, B12, and C.

With respect to Brazil in the period in question, it will be important to keep these important micronutrients in mind when examining cross-sectional variation in heights, since the traditional diet in Brazil's northern regions largely lacked in animal protein. Similarly, dietary patterns in those same regions tended not to include leafy green vegetables—important sources of iron. While it is possible to satisfy one's protein requirements with non-animal sources, the main starchy staple foods consumed in Brazil (rice, yams, and cassava) are deficient in lysine, one of the essential amino acids that is crucial for protein synthesis in the body, and hence, important for proper musculoskeletal development.[79]

Disease and Growth Restriction

Scholars and policymakers have long been interested in the links between disease and underdevelopment. When illness is widespread and prolonged within a population, it tends to reduce labor productivity and increase absenteeism from school. The World Health Organization lists diarrheal diseases, malaria, and intestinal parasites as the leading causes of chronic malnutrition and stunting in the developing world today.[80] In general terms, one can think of the cycle of disease and malnourishment amongst the

[79] Bender, *Nutrition: A Very Short Introduction*.

[80] Christine P. Stewart et al., "Contextualising Complementary Feeding in a Broader Framework for Stunting Prevention.," *Maternal and Child Nutrition* Suppl 2, no. 9 (2013): 27–45.

disadvantaged as a downward spiral; while disease curtails the body's ability to absorb nutrients, malnourishment reduces one's ability to stave off infection.

In assessing the effect of disease on heights, one must analyze the type and duration of infection. While acute illnesses such as the common cold would have little effect on heights, chronic infections can have a substantial negative effect. Heights are particularly sensitive to gastro-intestinal infections and other waterborne diseases of the oral-fecal mode of transmission to which infants and toddlers are highly susceptible.[81] Repeated exposure to enteric pathogens causes extended bouts of diarrhea, leading to nutritional malabsorption. Intestinal parasites such as hookworm also have a negative effect on heights through similar channels. The consequences of intestinal parasitic infections are especially debilitating during the adolescent growth spurt, since they directly divert nutrients from being absorbed into the body.[82]

Other common tropical diseases also exert a negative influence on stature. In a study on the nineteenth-century United States, Sok Chul Hong found that soldiers hailing from counties in which malaria was endemic were on average 1 inch shorter than those from areas of minimal to no infection.[83] The channels of causation have been confirmed by clinical studies that link chronic malaria to iron-deficiency anemia. Iron requirements are substantially higher during pregnancy and during the adolescent growth spurt, and the exhaustion of iron stores constrains vertical growth. Figure 2.2 displays an index of

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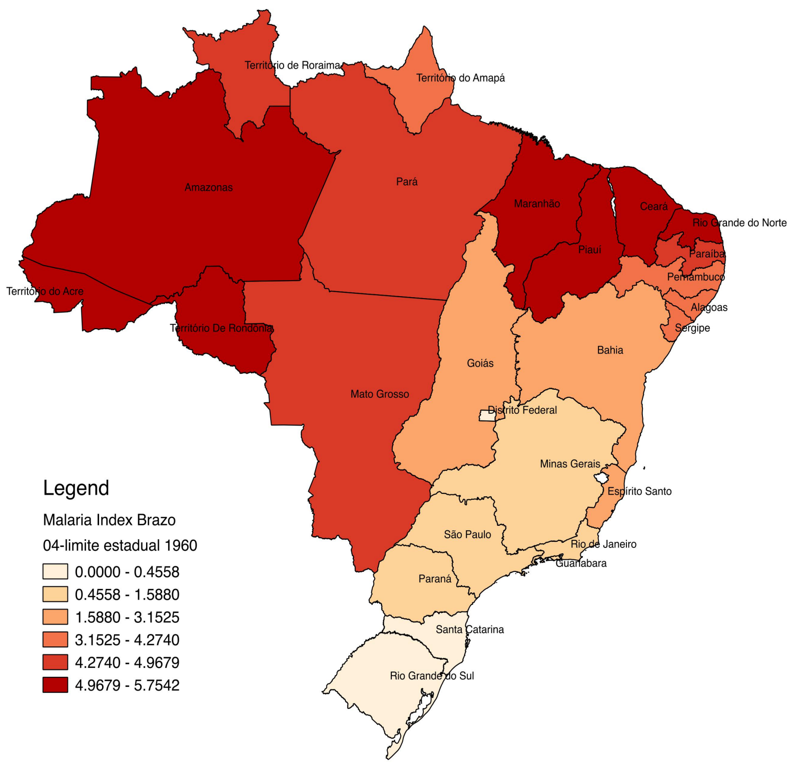
[81] We shall see in Chapter 6 that mortality data on infectious diseases are useful statistics to substantiate diminutions or improvements in heights.

[82] L. Stephenson et al., "TREATMENT WITH A SINGLE DOSE OF ALBENDAZOLE IMPROVES GROWTH OF KENYAN SCHOOLCHILDREN WITH HOOKWORM, TRICHURIS TRICHIURA, AND ASCARIS LUMBRICOIDES INFECTIONS," *Am. J. of Tropical Medicine and Hygiene* 41, no. 1 (1989): 78–87.

[83] S C Hong, "The Burden of Early Exposure to Malaria in the United States, 1850-1860: Malnutrition and Immune Disorders," *Journal of Economic History* 67, no. 4 (December 2007): 1001–35.

malarial stability for Brazil, pointing to a far heavier burden of the disease in the North and Northeast.[84] Based on this evidence, we might expect to see reduced stature of soldiers hailing from malaria-endemic regions, as Hong found for the Southern US.

Figure 2.2



Additional Considerations

Work intensity, especially manual labor performed in the growing years, is also important in determining stature by diverting nutrients away from physical growth. The loss of energy due to work is an especially pertinent consideration for pregnant mothers working in agriculture and for children engaged in the labor force before their adolescent growth spurt. In Brazil during the period studied here, children entering into agricultural work prior to their adolescence likely experienced attenuated adolescent growth spurts, as

[84] Anthony Kiszewski et al., "Global Index Representing the Stability of Malaria Transmission," *American Journal of Tropical Medicine and Hygiene* 70, no. 5 (2004): 486–98. I kindly thank Hoyt Bleakley for sharing the state-level data on Brazil with me.

nutrients required for growth were diverted towards labor. In addition, the birthweights of children born to women engaged in agriculture or in arduous domestic service were likely lower than those born to women that did not work or had less physically-demanding occupations. Since physical exercise and stretching stimulate growth, maintenance also exerts an influence on heights (although we might expect that maintenance affects stature to a lesser degree than the other proximate causes discussed above).

We can add climate, a factor not fully understood at the time that Steckel comprised the schema, to the list of proximate determinants. Infants born to mothers who experienced the stress of extreme weather events such as hurricanes in pregnancy tend to have adverse birth outcomes.[85] One recent anthropometric study on Brazil found that extreme heat, drought, and excess rainfall all have a negative impact on birthweights.[86] To be sure, climatic extremes can also cause indirect effects on heights. For example, droughts as in eighteenth-century Mexico decreased the supply of foodstuffs, consequently raising food prices and reducing nutritional intake.[87] On the other end of the spectrum of climate extremes, floods have the capacity to increase the proliferation of diarrheal disease.[88] This will be an especially important factor for Brazil, where, even in the present day, flooding continues to pose an obstacle to securing safe supplies of water.

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[85] J Currie and M Rossin-Slater, "Weathering the Storm: Hurricanes and Birth Outcomes," *Journal of Health Economics* 32, no. 3 (May 2013): 487–503.

[86] Paula Pereda, Tatiane Menezes, and Denisard Alves, "Climate Change Impacts on Birth Outcomes in Brazil," *IDB Working Paper Series*, no. IDB-WP-495 (2014).

[87] A Challu, "Agricultural Crisis and Biological Well-Being in Mexico, 1730-1835," *Historia Agraria* 47 (April 2009): 22–44.

[88] S Cairncross and M Alvarinho, "The Mozambique Floods of 2000: Health Impact and Response," in *Flood Hazards and Health: Responding to Present and Future Risks*, ed. Roger Few and Franziska Matthies (Earthscan, 2006).

The factors affecting human growth are not only confined to individual, familial, or proximate causes; they also reflect broader processes imbedded in social development. As the first column in Figure 2.1 highlights, social and political factors also affect heights. Income can allow for better nutrition, or for a family to relocate to a more expensive area in which urban services such as sewage and clean drinking water are more accessible. Social legislation limiting child labor or providing the right to maternity leave would potentially increase population heights by increasing the amount of energy available for linear growth. In addition, measures of public health and hygiene are pivotal since they decrease the risk of contracting disease. It is important to stress the cyclical nature of the relationship between heights and their determinants. Income and hygiene, for example, affect heights. Heights affect cognitive development, personality, labor productivity, which in turn will influence one's earnings and child-rearing decisions.[89] For these reasons, trends in heights are best understood when examined from the perspective of the longue durée.

2.3. Studies in Anthropometric History

What have we learned about the evolution of heights and their determinants in history? From the health implications of the industrial revolution in England to the effects of abolishing apartheid in South Africa, anthropometric history has clarified a host of questions that long interested historians.[90] In the formative years of the discipline in the

[89] R. Steckel and R. Floud, eds., *Health and Welfare during Industrialization* (Chicago: The University of Chicago Press, 1997), Ch. 1.

[90] For anthropometric studies on England, see John Komlos, "Shrinking in a growing economy? The mystery of physical stature during the industrial revolution." *The Journal of Economic History* 58, no.

1980s, anthropometric histories focused on the connections between heights and income. Steckel conducted a cross-sectional study on height and per capita income. He compiled data from 56 height studies and per capita income estimates from 20 countries. The comparisons made were based on 1970 country-level independent variables: income per capita, Gini coefficients, and adult literacy. Steckel finds that income and height are positively correlated. In addition, he also finds a negative correlation between height and income inequality.[91] It will be interesting to observe if the evolution of income inequality in Brazil had any effect on stature.

In a seminal article, Robert Fogel displayed the importance of historical anthropometrics to the study of demographic trends. Prior to Fogel's paper, scholars debated the magnitude of the impact nutrition had on mortality rates in the US and Europe since 1700. The lack of a gap between the gentry and working classes with respect to mortality rates perplexed researchers, since the life expectancy gains caused by enhanced nutrition should have been more pronounced amongst laborers. Fogel's research emerged from a large-scale data collection project conducted by the Center for Population Economics. The project on nutrition complied observations on stature from colonial muster roles, Union Army records, amnesty records, the Ohio National Guard, regular US Army records, and coastwise manifests of purchased slaves. Fogel explored

03 (1998): 779-802. For South Africa, Noel Cameron, "Physical growth in a transitional economy: the aftermath of South African apartheid." *Economics & Human Biology* 1, no. 1 (2003): 29-42.

[91] Richard Steckel, "Height and Per Capita Income," *Historical Methods: A Journal of Quantitative and Interdisciplinary History* 16, no. 1 (1983): 1–7.

the link between mortality rates and stature, and he revealed that improved diet accounted for over 40 percent of the decline in mortality in England from 1800 to 1980.[92]

While many of the initial anthropometric studies emphasized height and real wage correlations, subsequent research discovered that heights could incline in times of economic stagnation, or decline in times of growth. Viewed in long term perspective, heights often evolve in a cyclical manner. In 1979, Sokolof and Villaflor were among the first to uncover evidence of cycles in heights, finding that the heights of American colonists were approaching the contemporary (1979) level in the lead up to the American Revolution.[93] In the 1980s, numerous studies were conducted on the "antebellum puzzle" in the US, the term coined by John Komlos to describe the sustained diminution in stature from the 1820s through the 1850s. The steady decline in stature during the antebellum period puzzled researchers since per capita net national product increased by nearly 40 percent between 1840 and 1870, while the agricultural sector saw elevated growth rates of 2.3 and 4.2 percent per year on average in the 1840s and 1850s, respectively.[94]

Writers have attempted to surmise the cause of the widespread deterioration in standards of living. Some speculate that the antebellum decline in stature resulted from a more virulent disease environment caused by market integration and urbanization, while others point to a decline in nutritional intake.[95] Many have illustrated the decline in

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92 Robert W Fogel, "Nutrition and the Decline in Mortality Since 1700: Some Preliminary Findings," *NBER Working Paper*, no. 1402 (1984).

93 Sololoff, K.L. and G.C. Villaflor, "Migration in Colonial America: Evidence from the Militia Muster Rolls," Social Science History, Vol. 6, (Fall 1982): 539-570.

94 J. Komlos, "Shrinking in a Growing Economy? The Mystery of Physical Stature during the Industrial Revolution.," *The Journal of Economic History* 58, no. 3 (1998).

95 For the effects of disease, see Timothy Cuff, *The Hidden Cost of Economic Development: The Biological Standard of Living in Antebellum Pennsylvania* (Farnham: Ashgate Publishing, 2005).

stature associated with the urban penalty, yet Yoo clarifies that rural dwellers, too, fell victim to the antebellum puzzle. The shift to commercial agricultural production for far-away markets implied a deterioration of nutritional status as market integration increased the proliferation of disease.[96]

Since the pioneering work on the US and England, the effect of industrialization on health has been one of the main topics in the historical anthropometrics literature.[97] While many researchers would agree that industrialization benefits the population in which it takes place over the long term, anthropometric historians debate the health implications associated with industrialization and urbanization.[98] While industrialization had a negative effect on stature in the US and England, in other cases the onset of industrial growth and increased urbanization 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.[99] In Sweden industrial expansion after 1870, coupled with improvements in hygiene and childcare, caused improvements in the biological standard of living.[100]

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[96] Dongwoo Yoo, "Height and Death in the Antebellum United States: A View Through the Lens of Geographically Weighted Regression," *Economics & Human Biology* 10 (2012): 45–53.

[97] R. Steckel and R. Floud, 1997. *Health and Welfare during Industrialization*. (Chicago: The University of Chicago Press, 1997).

[98] See Sophia Twarog, "Heights and Living Standards in Germany, 1850-1939: The Case of Wurttemberg," in Steckel and Floud, *Health and Welfare during Industrialization*.

[99] José-Miguel Martínez-Carrión and Javier Moreno-Lázaro, "Was There an Urban Height Penalty in Spain, 1840-1913?" *Economics & Human Biology*, Vol. 5, No. 1 (2007): 144-164.

[100] Sandberg, Lars G and Steckel, Richard H. "Was Industrialization Hazardous to Your Health? Not in Sweden!" in Steckel and Floud, *Health and Welfare during Industrialization*.

Studying nineteenth- and twentieth-century Japan, Honda analyzes the average recruit height at age twenty disaggregated by prefectural type (industrial, intermediate and agricultural). Throughout the period in Japan, recruits hailing from industrial areas displayed greater overall stature, and the gap increased over time. On the eve of the Second Sino-Chinese War (1937), industrial prefectures displayed a 2 centimeter height advantage. Honda speculates that higher real income for nonagricultural workers account for the urban-rural gap, in addition to the greater caloric requirements associated with agricultural labor.[101] In order to analyze the health implications of industrialization, Steckel urges researchers to consider the timing of industrial growth relative to the expansion of the germ theory of disease.[102] In the case of Brazil, as we shall see, industrialization and the implementation of bacteriological concepts of infectious diseases coincided roughly at the same time. In light of this fact, we may hypothesize that industrialization did not have the same adverse health consequences in Brazil as observed elsewhere.

López-Alonso uses human stature data from passport applications and military recruitment records to study historical heights in Mexico from 1850 to 1950, and she finds that income inequality worsened during the 1850-1950 period. On the one hand, living standards for the working classes did not accompany improvements in overall economic performance during the period of industrialization emphasized by the Díaz

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[101] R. Steckel, "Strategic Ideas in the Rise of the New Anthropometric History and Their Implications for Interdisciplinary Research.," *The Journal of Economic History* 58, no. 3 (September 1998): 803–21. Honda, Gail. "Differential Structure, Differential Health: Industrialization in Japan, 1868-1940," in Steckel and Floud, *Health and Welfare during Industrialization*.

[102] R. Steckel, "Strategic Ideas in the Rise of the New Anthropometric History and Their Implications for Interdisciplinary Research," *The Journal of Economic History* 58, no. 3 (September 1998): 803–21.

regime (1876-1910), but they did benefit from the welfare programs introduced by populist president Lázaro Cardenas in the 1930s. On the other hand, the living standards of the Mexican elite improved steadily throughout the hundred-year period.[103] One possible hypothesis might be that heights in Brazil would follow a similar trajectory, given similarities between the Cardenas and Vargas regimes.

2.4 Extant Historical Heights Studies for Brazil: A Critical Assessment

Several historical height studies on Brazil during the nineteenth and twentieth centuries have emerged in recent years; however, these studies have been based on generally localized sources, limiting their worth in explaining population health trends at the national level. Prison records, worker registration cards, and Navy inscription files formed the brunt of archival work on Brazil, while government surveys have also served as the basis for several studies focused on Brazil in the late-twentieth centuries. In this section, I describe the advantages and disadvantages of using these types of sources of historical heights vis-à-vis military documents.

Two historical heights studies on nineteenth-century Brazil have relied on records from the Rio de Janeiro city jail. Zephyr Frank produced a preliminary study based on roughly 1,000 observations, and later, Baten et al created an expanded sample with over 6,000 observations.[104] One major drawback to using prison records is related to prisoner bias, since we might expect that criminal activity depended on a certain level of stature

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103 Moramay López-Alonso, *Measuring Up: A History of Living Standards in Mexico, 1850-1950*. (Stanford, CA: Sanford University Press, 2012).

104 Zephyr Frank, "Stature in Nineteenth-Century Rio de Janeiro: Preliminary Evidence from Prison Records," *Revista de Historia Económica*, 2nd, 24 (2006): 465–89; J Baten, I Pelger, and L Twrdek, "The Anthropometric History of Argentina, Brazil and Peru during the 19th and Early 20th Century," *Economics & Human Biology* 7, no. 3 (December 2009): 319–33.

and physical robustness. Yet another downside has to do with the limitations of localized sources and the migrant bias generated by observing individuals from distant regions. In addition to this bias generated from migration, one other source of concern for the prison records is reporting bias—an issue not discussed by either of the authors. While conducting data collection for the military sample, I made a cursory examination of the Rio de Janeiro prison records, upon which I estimated that around 50 percent of the prison records contained height measurements. It is unclear whether the prisoners were measured before being jailed, or if their height measurements were taken from identification cards or other supporting documentation.

Analyzing the southern state of Rio Grande do Sul, Monasterio and Signorini utilized a random sample of more than 11,000 *carteiras de trabalho* (work registration cards) to study the evolution of heights from 1889 to 1920. The authors found that heights were relatively stagnant in the period in question—a finding that does not square well with the main hypothesis set forward for this study in Chapter 1. However, one noteworthy finding was that immigrants were not statistically distinguishable from native-born Brazilians.[105] As the authors warn, one of the main drawbacks to using worker registration cards to study historical heights is that the most extreme tails of the height distribution are potentially underestimated due to sample-selection bias. In Brazil during this period, the wealthiest individuals were not likely to use work registration cards, and it is probable that the poorest individuals worked informally (or in an agricultural setting in which registration cards were not necessary).

[105] Leonardo Monasterio and M. J. S. Signorini, "As Condições de Vida Dos Gaúchos Entre 1889-1920, Uma Análise Antropométrica.," *EconomiA, Selecta Brasília (DF)* 9, no. 4 (December 2008): 111–26.

Official government surveys have also served as the basis for multiple anthropometric studies on Brazil. Monasterio et al. used a sample of over 40,000 observations from the *Pesquisa de Orçamentos Familiares* (POF, the Family Budget Survey) and other official nutritional surveys to study the evolution of heights from 1940-1980. The body responsible for the survey, the Insituto Brasileiro de Geografia e Estatística (IBGE), employed a stratified random sampling procedure, which ensures that the survey is representative of the underlying population. However, it should be noted that this survey only allows for estimates of heights as far back as the 1940 cohort of birth. Although height is corrected for diminutions in the aging process, studies based on the POF and other related surveys can only make inferences regarding the secular trend in height based on the relative age of the individual at the time of the survey.[106]

Although the database lacks more longitudinal detail, the POF sample has the added benefit of documenting family income, allowing for a comparison of height and income inequality. Monasterio et al argue that income distribution worsened during the 1940-1980 period. The quintile average of heights increased as a whole, but unevenly, favoring the wealthier income groups far more than the poor. Monasterio and his colleagues find that six centimeters differentiated the richest from the poorest quintiles. In addition, they illuminate regional disparities; throughout the birth cohorts, heights from the North and Northeast tended to be 2 centimeters below the sample average.[107]

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[106] L Monasterio, L P F Noguerol, and C Shikida, "Growth and Inequalities of Height in Brazil, 1939-1981," in *Living Standards in Latin American History: Height, Welfare, and Development, 1750-2000*, ed. J. Coatsworth, A. Challu, and R. Salvatore (Cambridge, MA: Harvard University Press, 2010).

[107] Ibid.

Section 2.5 Conclusion

Given the many data limitations facing quantitative historians of nineteenth- and early-twentieth-century Brazil, this chapter has discussed the usefulness of research in historical heights. Our discussion began with an early-twentieth-century observer, Arthur Lobo da Silva, who described the physical attributes of Brazilian soldiers in an influential essay. Lobo da Silva assumed that the regions of Brazil would never be equal in terms of height due to fixed traits of diverse immigrant populations. Although the patterns of immigration in Brazil may have exacerbated height differentials between regions (as we shall see in Chapter 4), this chapter has demonstrated the errors in Lobo da Silva's logic. Heights at the population level are determined by nutritional status, not genetics.

This chapter provides the reader with a conceptual basis on research in historical heights in order to understand the discussion of trends in heights in the chapters that follow. As Eveleth and Tanner assert, "a well-designed growth study is a powerful tool with which to monitor the health of a population, or to pinpoint subgroups of a population whose share in economic and social benefits is less than it might be."[108] Now, our discussion will shift to the principal anthropometric dataset used in this dissertation, the AHEX military sample.

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[108] Eveleth, Phyllis B., and James Mourilyan Tanner. *Worldwide variation in human growth*. (New York: Cambridge University Press, 1976), 1.

Chapter 3. The Brazilian Military and the AHEX Dataset

Introduction

On December 10, 1916, a system of obligatory conscription was instituted in order to fill the ranks of the Brazilian army. Military officials had seen the difficulties of recruiting personnel in the tumultuous decades of the 1890s and 1900s, and progressive cadres of high-ranking officials sought to modernize the recruitment process, displacing the semi-penal methods of impressment that had prevailed throughout the Colonial and Imperial eras. In addition to establishing a lottery draft system to summon potential recruits for service, this new law also imposed a minimum height requirement (MHR) of 154 centimeters to be admitted into the army. As Petter Beattie argues, the draft system transformed military service from a "punitive to a preventative institution of social reform."[109] Once considered "soldiers of misfortune," the new draft lottery law, in theory, meant that military recruitment became more egalitarian.[110] One potential concern arising from this quest to modernize the military is that the conscription law may have altered the skill composition of the military, calling into question the validity of chronological height comparisons based on the military sample.

In this chapter, I survey the history of military recruitment in Brazil in the nineteenth and twentieth centuries and examine the general contours of the military sample collected for this study. It is important to understand the degree to which recruitment practices varied over the time period since modifications to the recruitment

[109] Peter Beattie, *The Tribute of Blood: Army, Honor, Race, and Nation in Brazil, 1864-1945.* (Durham and London: Duke University Press, 2001), 13.

[110] Ibid.

process could imbue the anthropometric sample with selection biases. If changes in recruitment altered the composition of the rank-and-file vis-à-vis that of the underlying population, additional controls and statistical techniques to account for such changes will be necessary in my analysis of the long-run trends in stature in the chapters that follow. In order to produce a valid depiction of changes in height over time, the observable characteristics of the military sample should correspond to the same traits of the underlying population to a reasonable degree. Thus, the main objective of this chapter is to discuss the extent to which the portrait drawn from the AHEX dataset accurately represents the average Brazilian. I argue that, although major shifts in recruitment practices took place over time, the composition of the military sample does not present evidence of severe sample-selection bias. Thus, the AHEX anthropometric dataset will offer the least biased vision of trends in height available for the nineteenth and early-twentieth centuries.

The chapter proceeds in three sections. First, Section 3.1 surveys the history of the military in Brazil's nineteenth and twentieth centuries. Secondly, in Section 3.2, I discuss the sampling procedure used to construct the dataset from archival inscription records. Then, Section 3.3 provides an overview of the characteristics of the soldiers included in the sample, drawing comparisons to census statistics where applicable. Lastly, Section 3.4 concludes.

3.1 Military Recruitment in Nineteenth- and Twentieth-Century Brazil

In order to fully understand the temporal height trends presented in the chapters that follow, military recruitment practices, and especially the composition of the

Brazilian military with respect to the underlying population, will require special attention. As noted above, the historiography of the Brazilian military reveals that recruitment practices varied over the nineteenth and twentieth centuries. In Imperial (and Colonial) Brazil, coercion served as the predominant method of filling the ranks of the military. Peter Beattie labels the nineteenth-century as "the era of impressment," when press gangs frequently ransacked the countryside for soldiers—a processed referred to as "nabbing time" in oral histories of the period.[111] According to historian Fábio Faria Mendes, military recruitment in eighteenth- and nineteenth-century Brazil followed the logic of the "old regime," by which the act of recruiting troops was marked by violence and arbitrariness.[112] Capturing the violence of forced military service, citizens commonly referred to dragooning as "the tribute of blood"—an expression that acquired new meanings in the nineteenth century. According to Mendes, "The expression [of the tribute of blood] evoked the bloody practices of forced recruitment, marked by violence and arbitrariness. The expression also recalled the problematic and uneven distribution of military duties, immersed in networks of exemption and privilege."[113] The purpose of this section of the chapter is to elucidate the inner-workings of these webs of exemption and privilege.

Prior to the advent of universal conscription in the early-twentieth century, historians agree that the general public regarded military service with scorn and resentment. Oppressive tactics, often involving corporal punishment, characterized the

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111 Ibid., Ch. 1.

112 Fábio Faria Mendes, "Encargos, Privilégios, E Direitos: Recrutamento Militar No Brasil Nos Séculos XVIII E XIX," in *Nova História Militar Brasileira*, ed. Celso Castro, Vitor Izecksohn, and Hendrick Kraay, 1a ed. (Rio de Janeiro: Editora FGV, 2004), 114.

113 Ibid., 111.

control and administration of the rank and file during the era of impressment. The low pay, inability to honor contracts, and the poor treatment of the soldiers loomed large in the public's understanding of service in the army. Victims of dragooning were most frequently unemployed, unskilled laborers, or the "unprotected" poor—those unassociated with a *coronel*, or a regional political strongman.[114] Mendes asserts that individuals that were difficult to track and locate became the targets of recruiters: "vagabonds, travelers, itinerant workers, and wrongdoers."[115]

After being pressed, the responsibility of proving immunity from service fell upon the recruit. Inductees were exempted from service if a patron or relative had the financial means to submit a petition to the *junta revisora de alistamento militar,* or the military enlistment review board.[116] Beattie summarizes the conditions meeting direct exemption: "The law exempted married men, only sons, seamen, merchants, students, and the overseers of plantations and cattle ranchers. As long as cowboys, carpenters, government employees, commercial employees, tailors, and fishermen actively plied their trades and demonstrated good behavior, they also enjoyed immunity from impressment."[117] In order to avoid direct recruitment, elite and middle-class Brazilians frequently became members of the National Guard.[118]

The endurance of impressment reflected the government's low bureaucratic capacity and the pervasiveness of indirect forms of governance based on patronage.

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114 Beattie, *The Tribute of Blood: Army, Honor, Race, and Nation in Brazil, 1864-1945*, 29.

115 Mendes, "Encargos, Privilégios, E Direitos: Recrutamento Militar No Brasil Nos Séculos XVIII E XIX." 115.

116 Beattie, *The Tribute of Blood: Army, Honor, Race, and Nation in Brazil, 1864-1945.*

117 Ibid., 29.

118 Ibid.

Throughout the nineteenth century, military officials consistently lamented the inability to find a sufficient number of recruits. Disease, death, and desertion depleted the stock of enlisted servicemen to such a degree that one military official declared that it was necessary to recruit ¼ of the total military manpower annually.[119] Throughout the nineteenth century, many soldiers saw their terms of service illegally lengthened. In 1858, some 13 percent of *praças*, soldiers at the private rank, were eligible to exit the service yet they had not been discharged. The inability to honor contracts constituted one of the main reasons for desertion. Even upon being pressed into service, it was difficult for military officials to maintain high numbers in the ranks due to high degrees of desertion. In the northeastern state of Alagoas in 1865, 680 men were recruited to serve in the Paraguayan War, yet only 422 made it to Rio de Janeiro for training, meaning that nearly 40 percent deserted.[120]

Although desertion was a major obstacle, simply finding eligible recruits was an added hindrance. In 1874, the Minister of War stated that it was necessary to convoke 20,000 men in order to obtain only 2,000 recruits. Dragooning gangs counted on catching as many individuals by surprise as possible. Without a surprise sweep, potential recruits simply hid in nearby forests. Others could make the case for exemption by self-mutilation, the falsification of documents, and last-minute weddings.[121] Mendes clarifies that it was not simply potential recruits that saw the army with aversion. Recruitment was often carried out despite resistance from the *coronéis*, or local power chieftains. While

[119] Mendes, "Encargos, Privilégios, E Direitos: Recrutamento Militar No Brasil Nos Séculos XVIII E XIX.", 123-4.

[120] Vitor Izecksohn, "Resistência Ao Recrutamento Para O Exército Durante as Guerras Civil E Do Paraguai. Brasil E Estados Unidos Na Década de 1860," *Estudos Históricos* 27 (2001): 84–109.

[121] Mendes, "Encargos, Privilégios, E Direitos: Recrutamento Militar No Brasil Nos Séculos XVIII E XIX." 125-6.

the potential soldiers themselves lamented the harsh conditions and low pay associated with direct service, the landholding elite viewed the military as antithetical to agricultural production. Revolts from various sectors of society illustrate the widespread discontent with government agents meddling in personal affairs.[122] Not only did popular resentment illustrate the aversion to military service, but the elite also colluded with the victims of dragooning. In 1865, the President of the Province of Minas Gerais sent a confidential letter to the War Minster, claiming that many recruited men were visited by important people of *mineiro* society—judges of the peace, priests, and doctors—who advised them on how to evade the guards and flee.[123]

Complications in mobilizing troops for the Paraguayan War (1864-70) highlighted the shortcomings of traditional recruitment practices. Although the undesired poor—migrants, mendicants, and vagabonds—were the target of recruitment traditionally, the volume of troops required for the Paraguayan War, however, exerted modifications of the relationship between the central government, *coronéis*, and their *agregados* (or clients in the context of patronage). On January 7th, 1865, Decree 3.371 established the military corpse of the *Voluntários da patria*, which was "intended to bridge the barriers of region and class, favoring the nationalization and democratization

[122] Izecksohn, "Resistência Ao Recrutamento Para O Exército Durante as Guerras Civil E Do Paraguai. Brasil E Estados Unidos Na Década de 1860." 92.

[123] Mendes, "Encargos, Privilégios, E Direitos: Recrutamento Militar No Brasil Nos Séculos XVIII E XIX."

of recruitment."[124] For the war effort, the central government manumitted some 4,000 slaves provided they honored their army contracts.[125]

Although the military attempted to organize a draft in 1874 and in 1908, a full-scale draft lottery was not implemented until 1916. At least conceptually, the socioeconomic composition of the rank and file may have changed insignificantly with conscription. Students of secondary or tertiary institutions were enrolled in *tiros de guerra*, or reservist shooting corps, which enabled them exemption from the draft. By means of membership in the National Guard before 1916 or in a *tiro de guerra* thereafter, the middle and upper classes were able to rely on legal safety nets to avoid service in the barracks. Below, I will inspect if the skill composition of the military shifted with respect to that of the underlying population.

Having discussed the history of the Brazilian military and its recruitment practices, our discussion now shifts to the strategies relied upon to construct the anthropometric dataset from archival military inscription files.

3.2. The Historic Military Archive (AHEX) and Sampling Strategy

Due to the abundant supply of military recruitment files, anthropometric historians most frequently turn to military records to construct their data sets. This dissertation, too, relies on a military height series of over 17,000 observations as its core data set, all of which pertain to male soldiers. I culled the data from the Army Historical Archive (AHEX, Arquivo Histórico do Exército), the final repository for *assentamentos*,

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124 Peter Beattie (1994) cited in Izecksohn, "Resistência Ao Recrutamento Para O Exército Durante as Guerras Civil E Do Paraguai. Brasil E Estados Unidos Na Década de 1860." 88.

125 Beattie, *The Tribute of Blood: Army, Honor, Race, and Nation in Brazil, 1864-1945*, 41.

or induction files, from the nineteenth century and the majority of those from the twentieth century. The AHEX only holds files from units that were completely decommissioned; records from units that were transformed or renamed are held at their respective barracks or regional command headquarters. Despite the richness of the holdings, the AHEX does not commonly cater to higher-volume lines of inquiry such as those required for research in anthropometric history. In fact, the majority of requests for materials largely originate from military historians seeking army officer, regiment or tactical information, or from family members seeking their kin's records.

Well-experienced practitioners within the discipline have warned of the challenges presented by anthropometric research in an archival setting. John Komlos has alerted of the challenging nature of archival sampling in anthropometric studies, since financial regulations often limit archival staff availability and thus the amount of documents one can request in a given period. He cautions: "Under such circumstances it can be very difficult to ascertain at the outset even how many data are available, and it can be often impractical to obtain a truly random sample under conditions that prevail in many archives."[126] Research constraints within the AHEX made the already tedious task of amassing a large primary data set even more daunting. The lack of an accurate catalog of the holdings made it difficult to determine the best sampling strategy. Balancing the necessity of maximizing data collection within short archival consultation hours, on the one hand, with the exigencies of collecting a random sample, on the other, made conducting anthropometric research at the AHEX a difficult undertaking. Despite these institutional constraints, the archival staff proved to be receptive and supportive of my endeavors. Without the support of the archivists, I would have been unable to fully

[126] Komlos, John. "How to (and How Not to) Analyze Deficient Height Samples: an Introduction"

exploit the holdings of the AHEX—a multitude of volumes of induction files from regiments spanning two centuries and the entire geographic area of Brazil—an ideal source for a national, long-run anthropometric study.

During the preliminary research phase, I relied on the archival staff to select volumes for consultation from select periods. During the second phase, the staff granted me access to the annex in which the volumes of *assentamentos* were stored. The annex is divided into two levels—the lower of which contains nineteenth century records, while the upper holds records from the twentieth century. Initially my strategy entailed creating an inventory of the stacks and using a lottery system to summon the materials. Implementing a lottery system proved unfeasible shortly thereafter since some ninety percent of my requests returned unusable documents: *assentamento* volumes that did not contain height information, medical records without physical characteristics, or unrelated materials ranging from regimental accounting books to internal bulletins and directives.

Familiarizing myself with the organization of the storage annex allowed me to improve the sampling process. After closer examination, I discovered that any given volume of *assentamentos* could at times be a continuation from a previous volume. Since the identifying officer only recorded physical traits when the soldier was first inducted, the continuations did not have the height data necessary for study. If the organization and functioning of the archive were limiting factors, the preservation of the materials themselves was a further hindrance. In the lower storage level that pertains to nineteenth-century records, I estimated that sixty percent of the books did not have spines, making it difficult to determine if the volume was one of *assentamentos*, and if so, from which regiment and company they originated. In the upper level that houses twentieth-century materials, roughly one-third of the volumes had no clear regiment indication.

In order to obtain volumes with appropriate anthropometric information, I mapped out the stacks of the storage facility and randomly drew two or three volumes from each. I resulted to hand-picking and opening the volumes in order to observe if they were *assentamentos* that contained physical characteristics. I then noted the location (stack, shelf, and position within shelf) of each selected volume to be summoned for consultation. If a particular stack contained records from a multitude of smaller military units, I chose one to two volumes per company. When possible, I used powers tests to determine if a particular cohort of birth contained a sufficient number of statistical observations for reliable parameter estimates.

For the nineteenth century, all new entries from each volume were included in the sample. Twentieth-century records presented an additional challenge; the closer to the present day, the more concentrated the records became with respect to region of origin. More specifically, there is an overabundance of regiments based in the state of Rio de Janeiro for soldiers incorporated after WWII. For such regionally-concentrated volumes, I implemented a screening strategy to suppress overly repetitive states of origin. Since records were generally assorted by first-name alphabetically, and there is no regional bias for first names in Brazil, I decided to page through the volumes and record the first 20 soldiers in the sample. Thereafter, I included one soldier from the barracks' domestic state; then skipping through, I recorded the next soldier from a non-domestic state. Sampling alternated by domestic and non-domestic states of origin in this manner.

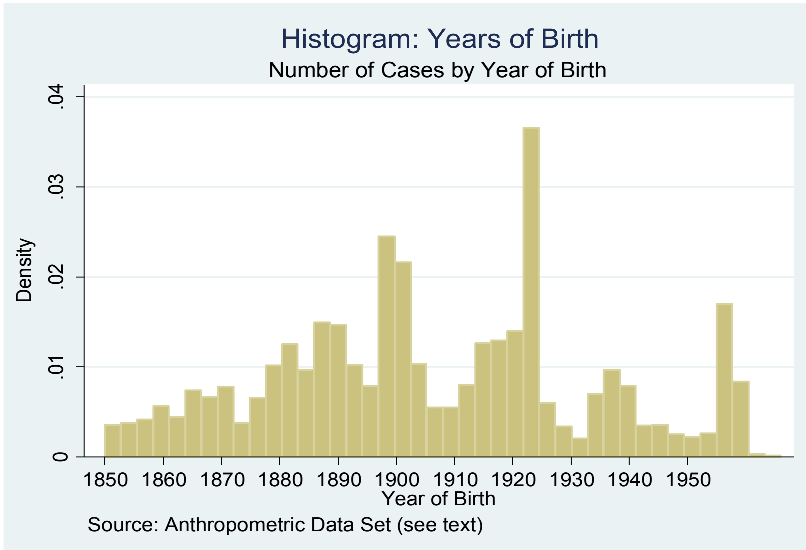
3.3. The military sample statistics

What general assertions can we make about the men included in the military sample? This section begins with a brief discussion of the origination of the documentation and the available information for research. Then, I discuss the military sample statistics in order to detail the main contours of the military height series.

Upon being inducted into the military, the *sargento identificador*, or the identifying sergeant, recorded pertinent personal information and physical characteristics of the soldier. Although several inhomogeneities in record keeping existed between regiments and over time, the recruitment files generally include the name of the soldier, the names of his parents (if known), his place and date of birth, skin color, height, occupation prior to entering the army, literacy status, vaccination history, mode of entry, and marital status. Files for recruitment years after 1916 more commonly reported the *município*, or municipality, of birth, literacy status, and vaccination history. After giving a brief overview on the number of observations by year of induction and birth, I present the distributions of the sample by recruitment regime. Subsequently, I present the statistical features of the military sample in terms of age, race, occupation, region, mode of entry into the military, marital status, and literacy.

In order to gauge changes in living standards over time, anthropometric historians most commonly divvy up height samples by birth cohort. For the military series, this study maintains a traditional convention of dividing the cohorts by decades of birth. As previously noted, my attempts at conducting a random sample were guided by obtaining an even spread of the archive's stacks and insuring that each cohort had sufficient data for regression analysis. Obtaining a sufficient number of observations in each cohort is important in order to yield the most reliable height estimates; for decades of birth in which there is insufficient data, anthropometric historians tend to exclude such periods.[127]

Figure 3.1



Graphical displays of the dataset provide a useful means of visualizing the number of observations corresponding to particular characteristics. Histograms delineating the frequency of cases within particular time periods illustrate the distribution of the sample by years of birth and years of induction. For a more complete overview of the sample statistics, consult Table 3.6 in the Appendix for this chapter. Figure 3.1 depicts the number of observations by birth cohort. With the exception of the 1850 and 1940 birth cohorts (which have roughly 433 and 663 observations, respectively), each decadal cohort has at least a thousand observations, with some well exceeding that mark. Despite the decadal fluctuations, each decadal cohort of the military sample contains a sufficient number of observations for statistical analysis.[128]

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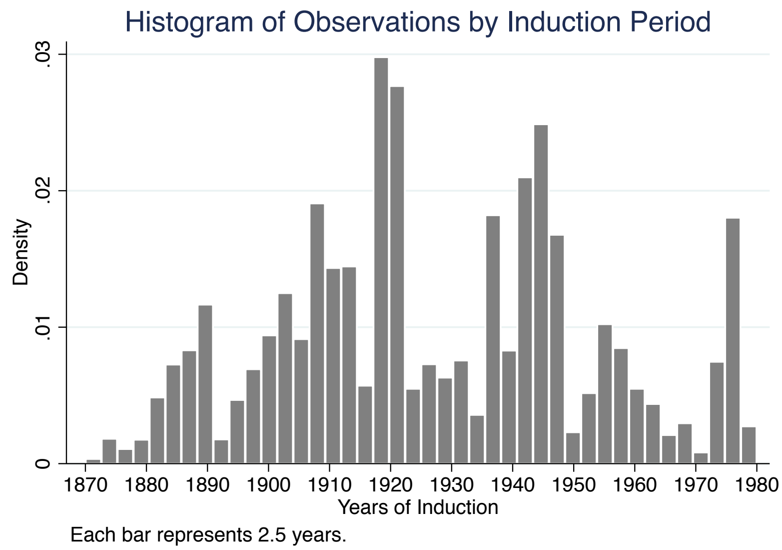
127 In their analysis on Brazilian prison records, Baten and coauthors discard cohorts of birth in which there were fewer than 50 observations.

128 Researchers working with historical heights generally agree that at least 30 observations are necessary to provide even a cursory estimate of average height in a given cohort of birth. See Baten,

Figure 3.2



Our analysis of the statistical contours of the sample also merits some discussion of the number of cases by recruitment year. An examination of trends by induction period can provide insights into pervading army recruitment practices. Further, and despite the lack of coherent official statistics on military recruitment during the study period, scrutiny of the sample by recruitment years can potentially clarify questions regarding sample-selection bias. If the number of cases included in the sample corresponds to major wars and other known periods of intensified recruitment, this is one indication that my archival sampling procedure induced little bias into the sample. Figure 3.2 displays the frequency of observations by recruitment year. It appears that major increases in the number of cases included in the sample appear to correspond to the exigencies of state formation in modern Brazil. The first major spike in the number of cases in the sample falls in 1890, the first entire year of the new First Republican government. The decades of 1890 and 1920 have the highest number of observations, with 2829 and 2896

J., Pelger, I., and Twrdek, L., "The Anthropometric History of Argentina, Brazil and Peru during the 19th and Early 20th Century.," *Economics & Human Biology* 7 (2009): 319–33.

observations, respectively, and wartime swells in recruitment likely accounted for their overabundance in the archive.

Historians suggest that the demand for military personnel generally responded to the outbreak revolts and regional insurgency movements in nineteenth- and early-twentieth-century Brazil, and the 1890s saw several such instances of political strife. For example, this period witnessed a short-lived civil war, the Federalist Riograndense Revolution (1893-94), in the southern state of Rio Grande do Sul. The military also responded to a separatist movement in an area of the Amazon contested by France, the Independent Republic of Guyana (1895-1900), which later became the state of Amapá. In the late 1890s, the military amassed a force of over 12,000 to quell the War of Canudos (1896-97), a millenarian rebellion in the northeastern state of Bahia.[129]

In addition to the large amount of soldiers inducted in the 1890s, a large portion of the sample corresponds to soldiers that entered the military in the 1920s and 1940s. While the nation engaged to some degree in other international conflicts, the two main wars in which Brazil participated during the period in question were the Tripartite War (1864-70) and WWII. Records from troops that fought in the Tripartite War have been lost or were for some reason not archived at the AHEX. The 1920s were also a rather turbulent time in Brazil in terms of regional revolts and political crises. The period was marked by the *Tenente* (literally, lieutenant) Movement (1922-30), so named after the young junior army officers that initiated a series of revolts against the senior officers beginning in 1922 and lasting until the Revolution of 1930, which signified the fall of the First Republic. In international matters, Brazil entered the Second World War in 1942

[129] Beattie, *The Tribute of Blood: Army, Honor, Race, and Nation in Brazil, 1864-1945,* 113.

and sent over 25,000 troops to take part in the conflict.[130] This fact likely accounts for the large number of recruits born in the 1920s and recruited in the late-1930s and early-1940s. There was relatively little documentation available for recruitment years in the late 1910s and late-1920s.

Having reviewed general patterns in the number of cases by periods of birth and recruitment, we can now scrutinize the outcome variable of interest: height. The distribution of the height measurements in the sample yields crucial insights into the reliability of the data. This is especially important to consider, since 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). However, since we know that military units commonly recorded height information as a means of identifying deserters (or deceased soldiers), and with the assumption that the post of *sargento identificador* required a degree of training to promote uniform recordkeeping and measurement, we can hypothesize that measurement error was low.

Despite not knowing the precise methodology of taking height measurements upon induction, we can look within the distribution to examine for traces of unreliable height measurements such as heaping (or digit preference, i.e., the clustering of measurements around particular values, such as 0s and 5s) and non-normality. In the following sections, I commonly divide the dataset by recruitment regime. Regime 1 pertains to soldiers inducted before the 1916 conscription reform, while Regime 2 denotes those inducted between 1916 and 1936, when the MHR was set to 154 cm.

130 Francisco C Alves Ferraz, "Os Veteranos Da FEB E a Sociedade Brasileira," in *Nova História Militar Brasileira*, 2004, 365–88.

Regime 3 represents soldiers incorporated after 1936, when the MHR was raised to 155 cm. Table 3.1 presents the frequency of height measurements by the last digit of the value.[131] The first column represents the entire AHEX sample, while the remainder correspond to particular recruitment regimes. In the absence of any digit preference, we would expect to see all of the last digits (0-9) account for 10 percent of the total frequencies. In the total sample, measurements ending in 0 account for 15.41 percent, while those ending in 1 account for only 7.77 percent. However, the presence of digit preference was not uniform throughout recruitment periods. In Regime 1, values ending in 0s and 5s represent, collectively, 32.15 percent of the sample, while in Regimes 2 and 3, the same digits accounted for 25.9 and 26.58 percent, respectively. 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.

Table 3.1

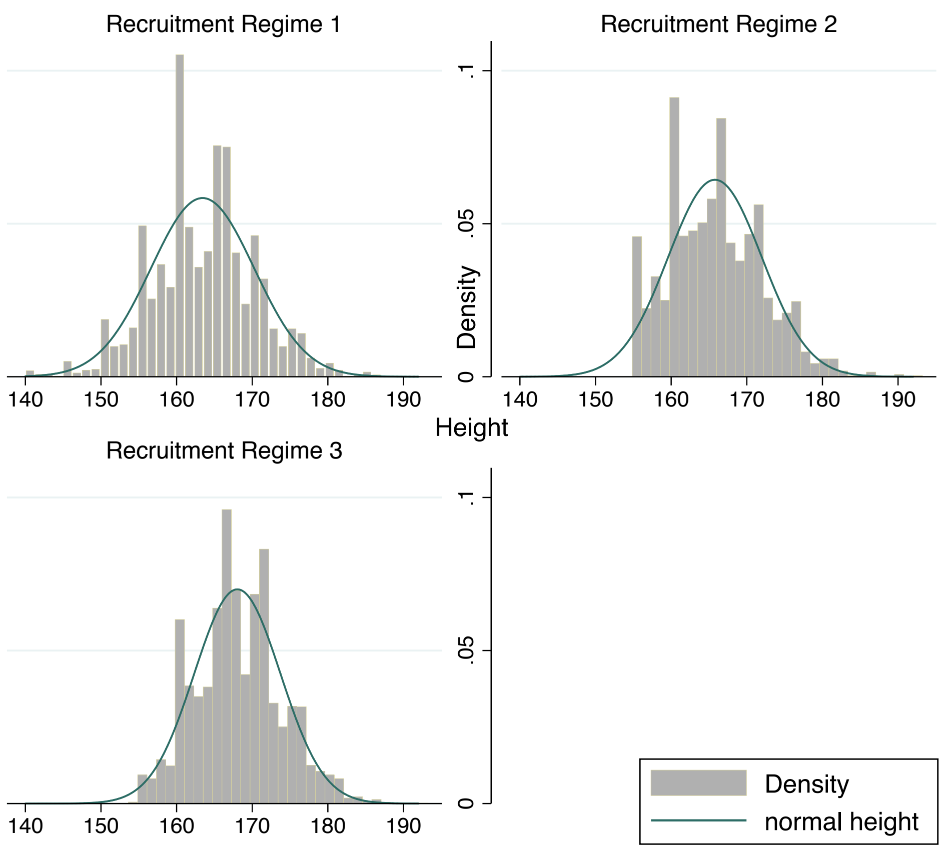
Analysis of Digit Preference in the AHEX Sample

Last Digit	Total		Regime 1		Regime 2		Regime 3	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
0	2,574	15.41	1,019	18.24	591	13.57	964	14.27
1	1,298	7.77	359	6.43	378	8.68	561	8.3
2	1,711	10.25	569	10.18	425	9.76	717	10.61
3	1,489	8.92	480	8.59	420	9.64	589	8.72
4	1,354	8.11	438	7.84	366	8.4	550	8.14
5	2,148	12.86	777	13.91	537	12.33	834	12.34
6	1,600	9.58	523	9.36	446	10.24	631	9.34
7	1,395	8.35	453	8.11	383	8.79	559	8.27
8	1,827	10.94	570	10.2	449	10.31	808	11.96
9	1,303	7.8	399	7.14	360	8.27	544	8.05
Total N	16,699		5,587		4,355		6,757	

[131] For example, height measurements of 160 and 170 are grouped in the 0 category, values of 163 and 153 are grouped in the 3 category, and so forth.

One important feature of height samples is that they generally follow the bell-shaped curve of a standard normal distribution.[132] If heights in the military sample are normally distributed, we can accept this as evidence to support the validity of the soldiers' height measurements. Disaggregating the distributions by recruitment regime, Figure 3.3 will confirm the standard normal distribution of heights in the military sample. An additional display of the distributions of height by recruitment period is found in Figure 3.10 in the Appendix to this chapter, which superimposes kernel-density estimates by recruitment regime on the same graph. Interestingly, this figure reveals a bi-modal distribution, with measures of central tendency differing between Regimes 2 and 3.

Figure 3.3



132 J. Komlos, "How to (And How Not To) Analyze Deficient Height Samples: An Introduction," *Historical Methods: A Journal of Quantitative and Interdisciplinary History* 37, no. 4 (2004): 160–73.

Our next glimpse at the dataset will consider the most common ages of soldiers included in the sample. Table 3.2 displays the number of cases in the military sample by age and recruitment regime. The first column provides the ages of soldiers for the entire military samples, while the remaining columns parse the age distributions by recruitment regime. Over the entire period under study, the median age of soldiers was 19 years of age (representing 21 percent of the distribution). One puzzling aspect of the age distribution is found in the number of cases for soldiers below the age of 18, since soldiers were only pressed into service if they were above that age.[133] Soldiers under the age of 18 at the time of enlistment represented roughly 2.5 percent of the sample, although this percentage is more concentrated in Regime 1, prior to the emergence of the system of universal conscription. During the 19th century, the officers that commanded the barracks frequently filed complaints about being shorthanded. It is therefore possible that a small number of younger soldiers were inducted into the military to perform menial tasks around the barracks and receive training prior to being officially of age to join. Even in the era of conscription (Regimes 2 and 3), there were 126 soldiers aged 17 and below. In present-day populations, adults tend to reach terminal adult stature by the late teen years; however, in many countries economic historians have found that terminal height was not reached until the early twenties (commonly, at roughly age 22). For this reason, the regression analyses performed in the next chapter will take the ages of the younger recruits into account.

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[133] While not displayed here, 23 cases pertained to soldiers under the age of 14. Due to the limited number of cases in those age groups, cases for soldiers under the age of 14 were discarded.

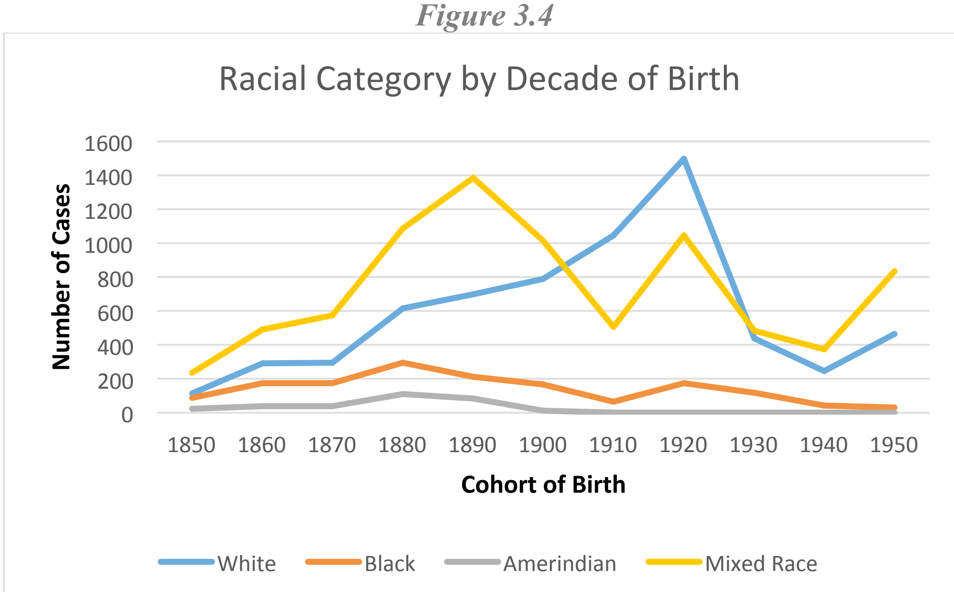
Table 3.2

Ages of Soldiers by Recruitment Regime								
	Total		Regime 1 (1870-1916)		Regime 2 (1916-1936)		Regime 3 (1936-1980)	
Age	N	%	N	%	N	%	N	%
14	12	0.07	12	0.22	0	0	0	0
15	29	0.18	25	0.46	4	0.09	0	0
16	58	0.35	53	0.97	1	0.02	4	0.06
17	308	1.88	191	3.51	50	1.16	67	1.01
18	887	5.41	467	8.57	207	4.79	213	3.22
19	3,442	21	444	8.15	383	8.87	2,615	39.48
20	2,073	12.65	534	9.8	345	7.99	1,194	18.03
21	2,513	15.33	739	13.56	1,046	24.22	728	10.99
22	2,558	15.61	670	12.3	1,237	28.64	651	9.83
23	1,610	9.82	513	9.42	449	10.4	648	9.78
24	793	4.84	355	6.52	248	5.74	190	2.87
25	554	3.38	308	5.65	112	2.59	134	2.02
26	380	2.32	251	4.61	69	1.6	60	0.91
27	270	1.65	156	2.86	69	1.6	45	0.68
28	260	1.59	177	3.25	48	1.11	35	0.53
29	176	1.07	143	2.62	18	0.42	15	0.23
30	155	0.95	127	2.33	20	0.46	8	0.12
31	72	0.44	64	1.17	3	0.07	5	0.08
32	55	0.34	49	0.9	2	0.05	4	0.06
33	41	0.25	40	0.73	1	0.02	0	0
34	38	0.23	34	0.62	3	0.07	1	0.02
35	39	0.24	35	0.64	1	0.02	3	0.05
36+	68	0.4	61	1.12	3	0.07	4	0.07

I collected the skin color of the recruits in order to delineate racial subcategories. Typical of any large slave-holding nation, many historians argue that race and socioeconomic status in Brazil are vastly interrelated. While there existed a potential for skin color to shed light on racial inequalities in health status, racial differentiation in Brazilian history is highly complex given the degree of miscegenation, as well as the degree to which racial identities shifted over time. Before categorizing the data, I logged

23 descriptors for skin color, ranging from *cabocla* (mixed race/indigenous), to *preta* (black) or *fula* (bronze-colored), with a vast spectrum of mixed race gradations (*parda clara* or light brown, *mulata*, *morena escura* or dark brown, etc.).[134] In order to facilitate regression analysis, I collapsed the reported descriptors of skin color into four racial categories in order to match census classifications: white (*branca*), Amerindian (*cabocla*), mixed race (*parda*) and black (*preta*). A full list of the uncollapsed skin color descriptors can be found in the appendix to this chapter. The racial categories from the military sample that were collapsed to match census descriptions appear in Figure 3.4 by cohort of birth. Soldiers of mixed-race ancestry comprised the majority of the sample throughout the nineteenth century, followed by whites. From the 1910 to 1930 birth cohorts, whites were the majority, while in the latter cohorts, mixed-race individuals were most abundant. Although complexion was not self-reported, the multitude of recorded categories calls into question the inter-rater reliability of racial classification in a population with a complex process of miscegenation.

Figure 3.4



[134] See Table 3.7 in the Appendix to this chapter

The occupations that the soldiers reported upon induction yield some important insights into their socioeconomic statuses. Fogel et al. posit that occupational subgroupings rest on the assumption that intergenerational mobility is low, since height more adequately reflects crucial periods of childhood and adolescence. The line of reasoning would imply that taking the soldier's occupation as an indication of his upbringing presumes that he would have roughly the same skill set as his father (or mother). While we would not expect this to be the case for Brazil during the period under question, the documentation does not list parental occupations, only those of the inductees. Although one would more adequately utilize parental occupation, López-Alonso points out that those parents that provided skills for their children also likely provided better nutrition and health.[135] Therefore, we can take the occupation of the soldier as a loose descriptor of his family's socio-economic status.

Table 3.3 provides a list of common occupations reported in the military induction files with corresponding information on the inferred occupational category and number of cases. The most common occupation reported in the military files was "no occupation." Prior to the 1900 cohort of birth, soldiers without any profession listed constituted between 15 and 25 percent of the entire sample. The overabundance of soldiers without occupational information poses an obstacle to determining familial socio-economic status from soldiers' reported occupations. The main issue at hand is determining whether the multitude of soldiers listed without occupations truly had no occupation prior to enlistment. Because several records pertaining to soldiers born in the

[135] Fogel, "Nutrition and the Decline in Mortality Since 1700: Some Preliminary Findings"; Moramay López-Alonso, *Measuring Up: A History of Living Standards in Mexico, 1850-1950* (Stanford, CA: Stanford University Press, 2012).

nineteenth century neglected this portion of the individual characteristics, the large number of recruits without occupations must be taken with a grain of salt.

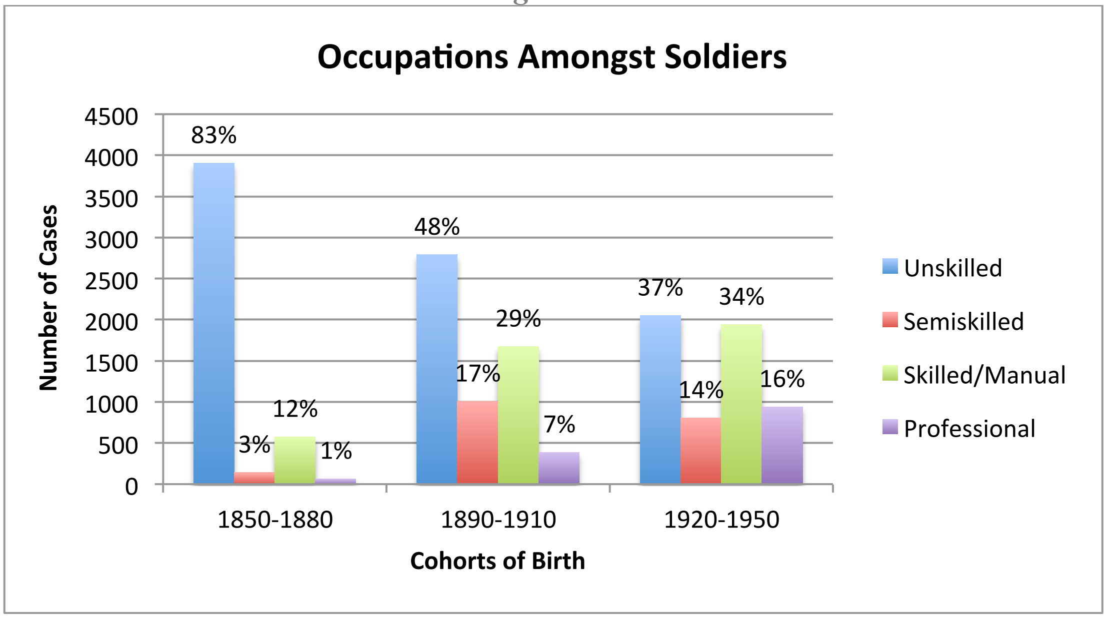
Table 3.3

Common Occupations Amongst Soldiers			
AHEX Occupation	**English Translation**	**Category**	**N**
Sem ofício	No occupation	Unskilled	7062
Lavrador	Tiller, peasant	Unskilled	1700
Trabalhador	worker, laborer	Unskilled	67
Agricultor	Farmer	Unskilled	680
Pedreiro	Mason	Semiskilled	384
Operário	Operator	Semiskilled	449
Jornaleiro	Paper delivery man	Semiskilled	102
Pescador	Fisherman	Semiskilled	29
Comércio	Commerce, retail	Skilled	892
Sapateiro	Shoemaker	Skilled	
Carpinteiro	Carpenter	Skilled	202
Mecânico	Mechanic	Skilled	117
Motorista	Chauffeur, driver	Skilled	257
Estudante	Student	Whitecollar	873
Funcionário público	Civil servant	Whitecollar	81
Datilógrafo	Typist	Whitecollar	141
Guarda-livros	Bookkeeper	Whitecollar	48

Conceivably, the military had little use in keeping consistent records on occupation once an individual was approved for service. Since the identifying officer asked the recruit for "successive occupations prior to joining the military," it is plausible that a number of cases denoting no occupation for the recruit may have been improperly designated. Even though the possibility exists that some soldiers without occupations were gainfully employed, for the purposes of this study I have assumed that those without any listed occupation were unskilled. Although the majority of the recruits were unskilled, we can observe that a number of skilled and white-collar men entered into military service as well.

After establishing this general depiction of the skill composition of the military sample, it is pertinent here to highlight the degree to which the skill distribution varied over time. To that end, Figure 3.5 details the number of cases by occupational category and groups of birth cohorts that roughly correspond to recruitment regimes. One can discern that unskilled occupations constituted the vast majority of the sample, over 83 percent, in the birth cohorts ranging between 1850 and 1880. The share of skilled soldiers in the same period was only 12 percent, while semi-skilled soldiers represented 3 percent and professionals accounted for just over 1 percent of those recruited in that period. In the second recruitment period (corresponding to birth cohorts from 1890 to 1910), the share of unskilled soldiers declines to 48 percent, while the share of skilled amounts to 29 percent. Semi-skilled recruits in that period represented 17 percent of the total, while professionals accounted for only 7 percent. In the third period, the share of unskilled soldiers in the total sample continues to decline to 37 percent, while skilled soldiers accounted for over 34 percent. Semi-skilled soldiers accounted for 14 percent in this period, while professionals amounted to over 16 percent. In the cohort of 1910 skilled-manual occupations become most prominent with semi-skilled occupations coming in at second place.

Figure 3.5



One point of concern raised by the shift in the occupational structure of the military sample is related to selection bias. The advent of universal male conscription in 1916 gave a larger role to keeping consistent records on recruitment. Since the observed increase in skill level is roughly contemporaneous with Brazil's initial industrial growth spurt and the transition to universal conscription, it is difficult to tell if the increase in semi-skilled and skilled professions is due to better reporting and recordkeeping within the military, improvements in the skill-structure of the underlying population, or a shift to a more egalitarian distribution of military service (which would incorporate more skilled and middle-class Brazilians). Our discussion here will not delve into the answer to this question, since Chapter 4 will tackle issues of selection bias more concretely. For the purposes of this statistical overview, I will compare the skill composition of soldiers included in the military sample to that enumerated in census records. Making these comparisons will yield important clues regarding the selectivity of military recruitment over time.

Table 3.4

Sample Occupational Distribution Compared to Census Statistics

AHEX 1850-1880	**% Sample**	**1872 Census**	**% Population**
Professional/ Whitecollar	1	Professional/Whitecollar	0.9
Skilled/Semi-Skilled	15	Skilled/Semi-Skilled	18.9
Unskilled	83	Unskilled	80.2
AHEX 1890-1910		**1920 Census**	
Professional/ Whitecollar	7	Professional/Whitecollar	2.2
Skilled/Semi-Skilled	46	Skilled/Semi-Skilled	10.2
Unskilled	48	Unskilled	87.9
AHEX 1920-1950		**1940 Census**	
Professional/Whitecollar	16	Professional/Whitecollar	11.8
Skilled/Semi-Skilled	48	Skilled/Semi-Skilled	36.1
Unskilled	38	Unskilled	52.7

The left-hand column of Table 3.4 provides the percent distribution of the occupational categories listed in the AHEX documentation disaggregated by grouped cohorts of birth. The right-hand column reports the distribution of the underlying population by occupation category for the census closest to the recruitment period.[136] One can observe that the occupational distribution of the AHEX sample in the initial recruitment period deviated little from that of the underlying population (as compared with the 1872 census). In the second recruitment period, the sample occupational distribution is heavier in the skilled and white-collar categories than we would expect given their share in the underlying population. Unskilled soldiers constituted only 48 percent of the military sample, while that same category represented 89 percent of the census population. This may result because the 1920 census began to enumerate occupational categories in a different manner.[137] Additionally, there was an

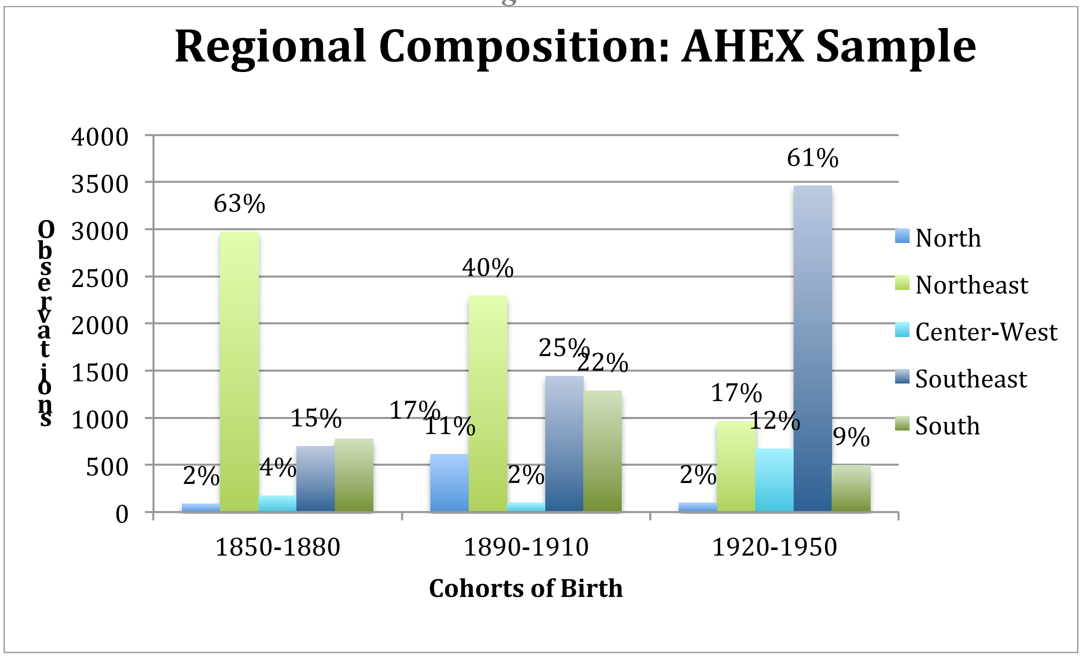
[136] By nature, the occupational distribution of an economy undergoing modernization will evolve from year to year as primary sector employment declines.

[137] Merrick and Graham, *Population and Economic Development in Brazil: 1800 to the Present*.

unprecedented increase in the proportion of individuals not reporting any profession between 1900 (44 percent) and 1920 (69 percent), perhaps indicating that the deficiencies in the 1920 census were the culprit of the large unskilled percentage observed in that year. It seems unlikely that the share of unskilled individuals in the censuses would increase from 80.2 percent in 1872 to 89.9 percent in 1920. Consequently, we must examine the 1920 census figures with caution. Census discrepancies aside, the occupational distribution of the military sample in the third recruitment period appears to be much more on par with the underlying population. Summing up, when we examine the occupational distribution of the military sample in comparison with the available census statistics, we can see an increase in the skill composition relative to the underlying population, with the AHEX sample denoting a larger share of recruits from the semi-skilled and skilled categories. However, the 1920 census may be relatively inaccurate. In the next chapter, I will rely on methods to produce adjusted height estimates in order to take changes in the skill composition of the AHEX sample into account.

While there was a shift in the occupational distribution of the military sample over the time period, there was also a shift in the regional composition of the soldiers. Sampling included soldiers from all of the geographic administrative areas of Brazil, and I utilize the 5 main regions stipulated in Brazilian censuses—the North, Northeast, Center-West, Southeast and South—to isolate the soldiers by region of provenance. Figure 3.6 depicts soldiers by region and decadal cohort of birth.

Figure 3.6



Accounting for nearly two-thirds of the sample, soldiers hailing from the Northeast far outnumbered any other region in the initial recruitment period. Those hailing from the Southeast represented only 15 percent of the sample in this period, while those from the South accounted for 17 percent. Soldiers from the North and Center-West represented between only 2 and 4 percent, respectively. The proportion of Northeastern soldiers in the sample declines to only 40 percent in the second recruitment period, while that of Southeasterners increases to 25 percent and that of Southerners increases to 22 percent until 1910, when soldiers from the Southeast became most common. For the majority of the nineteenth century, the Northeast accounted for roughly two-thirds of the total sample, while the South and Southeast represented between 10-20 percent, respectively.[138]

[138] A comparison of the regional distribution of the anthropometric sample with demographic trends of the total Brazilian population reveals that the sample does not deviate significantly from the underlying population. Exceptions to this rule include the cohort of 1890, when the North accounted for a disproportionally large amount of the sample, and cohorts 1940 and 1950, when an excessive

A comparison between the regional distribution of the sample and available statistics on military recruitment by region substantiates the validity of the dataset. Table 3.5 compares census data and official statistics on military recruitment with the regional distribution of the AHEX sample.

Table 3.5

Region	AHEX Regime 1[a]	1870-82 Recruits[b]	1872 Census[c]	AHEX Regime 2[a]	1916 Recruits[b]	1920 Census[c]
Northeast	63	52.5	45.7	40	20.8	36.7
Southeast	15	16.3	40.5	25	29.2	44.6
South	17	19.7	7.3	22	41.8	11.5
Center West	4	5.8	2.2	2	5.1	2.5
North	2	3.8	3.4	11	3.1	4.7

Sources: [a] AHEX dataset; [b] Recruitment statistics cited in Beattie (2001) p. 246; [c] Official census data (IBGE) cited in Klein and Vidal Luna (2014) p. 30.

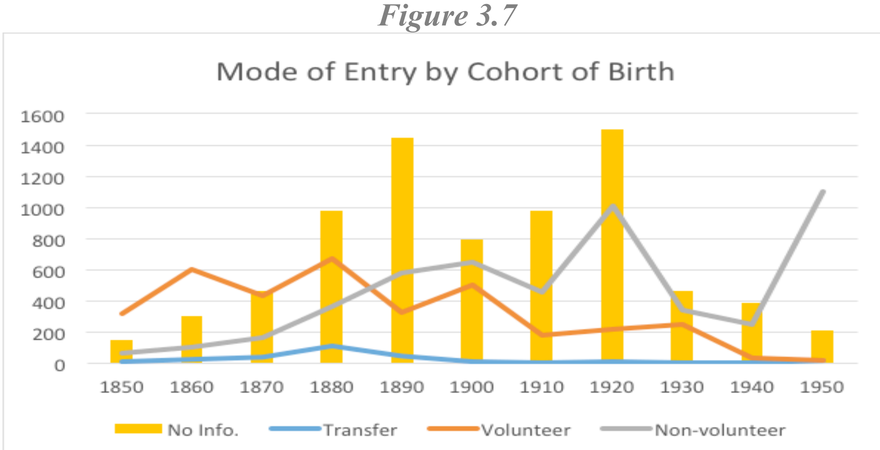
In general terms, the regional composition of the AHEX sample reflects the regional composition of the underlying population to a large degree, even though the Southeast and South were underrepresented in the dataset in Regime 2.

Additional information of potential use in the recruitment documents are the mode of entry, civil status, vaccination history, and literacy status. Consistent reporting of these characteristics would provide additional socioeconomic details of the soldiers; however, many of the documents failed to report such information. My initial hypothesis was that the method by which a soldier entered the military would help isolate those that were pressed into military service before universal conscription was enacted in 1916. However, the language used to describe the mode of entry in the nineteenth century was

share came from the Center-West. In the 1910 cohort the South similarly represents a larger portion of sample than one would expect given its underlying population share.

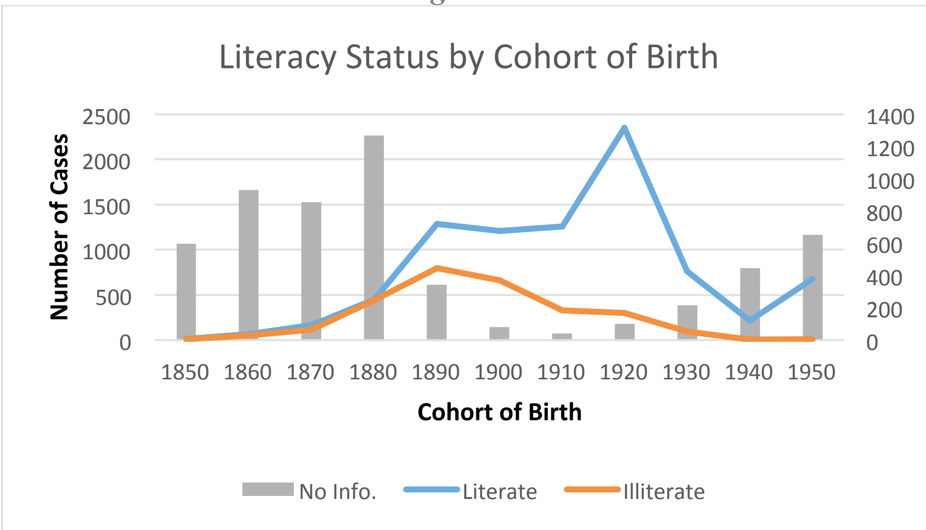
frequently ambiguous.[139] Moreover, many of the nineteenth-century records did not provide information on the mode of entry. Figure 3.7 charts mode of entry by decade of birth of the military sample. The number of cases by mode of induction appears to be consistent with what we might expect given the transition to universal conscription in 1916. Those coded as volunteers outnumbered non-volunteers prior to 1890, while non-volunteers become most common thereafter. For those recruited before 1916, the category of non-volunteers represents soldiers that were pressed into service, while the same category denotes those that were conscripted after the 1916 conscription reform. While the number of non-volunteers supersedes that of volunteers in the 1890 cohort of birth, the number of volunteers remains high through the 1910 cohort. It is worth noting that even in the initial period under study during which there was no system of conscription, volunteer soldiers far outnumbered those that were impressed. However, one caveat applies regarding the interpretation of mode of entry, particularly prior to the 1916 reform. For a large number of cases, it was impossible to determine mode of entry.

Figure 3.7



[139] In some cases, the documents state that the soldier "joined the army as a private voluntarily" while others indicated that the soldier "was sent to join the army as a private voluntarily."

Figure 3.8



Literacy status is one additional potentially important attribute recorded in the military files. Economic historians frequently make use of literacy as an important marker of educational opportunities in the early-life environment. In terms of direct causality, the education of the individual being measured is of little importance for his or her terminal stature, primarily because heights are largely determined before educational decisions are made (before age 3). Recent research on the Rosenwald schooling campaigns in the early-twentieth-century US South revealed that soldiers with access to primary schooling were no taller than those without access to primary education.[140] However, the educational level of the individual's parents is highly important: "Education (literacy) has an effect, because better educated parents have superior consumption skills, are better informed about long-range health effects of consumption patterns, and, thus, are usually able to take better care of their off-springs."[141] Costa was

140 Daniel Aaronson and Bhashkar Mazumder, "The Impact of Rosenwald Schools on Black Achievement," *FRB Chicago Working Paper*, no. No. 2009–26. (September 2011).

141 Komlos, "How to (And How Not To) Analyze Deficient Height Samples: An Introduction."

the first to link military records to census data for the US, and she revealed a large height advantage for those soldiers born to literate mothers.[142]

Although parent literacy status is unavailable in the military sample, I take recruit literacy as an important indicator of parental investment. Akin to López-Alonso's reasoning on occupation, parents that could afford to send a child to school and forego the extra income the child would earn in the workforce likely invested more in the child's welfare. The literacy status of the soldier, however, was inconsistently reported in the documentation, making it more difficult to infer general trends in literacy. Figure 3.8 depicts the ratio of literate to illiterate soldiers, as well as those without any information, by decade of birth. Until the 1880 birth cohort, those with no information on literacy status were the majority in the sample, while literate soldiers accounted for more than two-thirds of the sample from the 1890s onward. Since roughly 15 percent of the population was literate in 1890, recruiting officers most likely ignored literacy status in the late-nineteenth century. When conducting statistical analyses with inconsistently reported variables in the next chapter, I speculate that their spotty reporting will render the variables for mode of entry, civil status, and literacy statistically insignificant.

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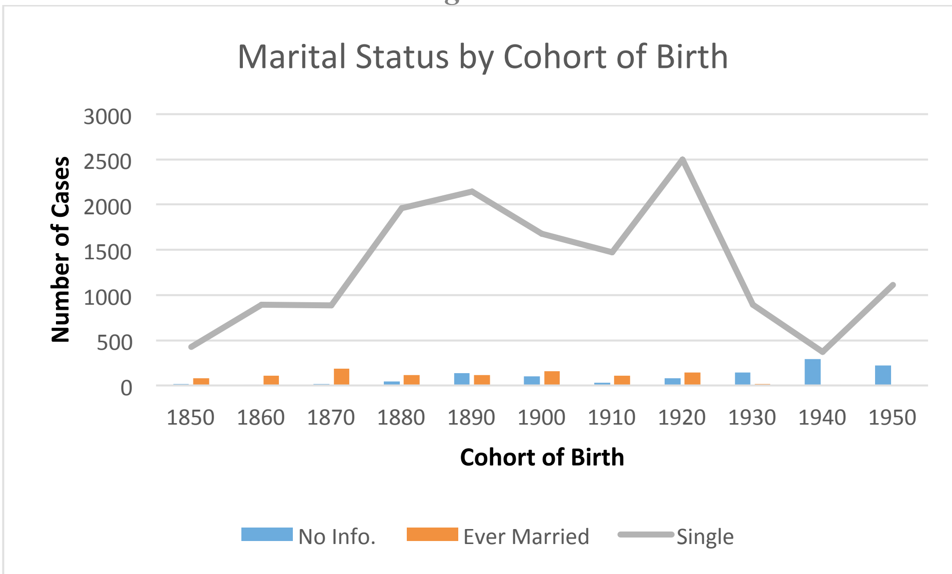
142 Dora Costa, "Height, Wealth, and Disease among the Native-Born in the Rural, Antebellum North," *Social Science History* 17, no. 3 (Autumn 1993): 355–83.

Figure 3.9



I use civil status to differentiate between single and ever-married soldiers. This information is useful for our study on the anthropometric history of Brazil since many economists and historians agree that the better off married younger. Figure 3.9 illustrates the marital status by decade of birth of the military sample. Single recruits were by far the most common throughout the study period. The amount of ever married soldiers (that is, those married, divorced, or widowed at the time of service) is miniscule in comparison. The number of cases for which there was no information on marital status were very few in comparison to those that lacked information on mode of entry, literacy, vaccination history, and other individual attributes. This is likely the case because military bookkeepers had more of an incentive to record marital status since it was used in determining one's eligibility for military service, pay level, and time of contract. The data on marital status reveal that few married (or widowed) soldiers enlisted in the military over the entire 1850-1950 period. Also, one may note that a large increase in married recruits occurred in the birth cohort of 1870, reflecting the swell in recruitment associated with the 1890s.

3.4 Conclusion

Broadly, this chapter considers the representativeness of the military sample as a whole and scrutinizes changes in recruitment practices over time. Our discussion began with a brief historical overview of the Brazilian military and its recruitment practices in the nineteenth and twentieth centuries. The historiography related to the military in Brazil during this period documents a shift in recruitment practices. The conscription law of 1916 is of the utmost importance for the analysis of long-term trends in height based on this sample, since it has the potential to change the skill composition of the sample with respect to the underlying population. After providing this historical background, I elaborated on the sampling method used to construct the AHEX dataset from archival records. Then, I discussed the socio-demographic traits of the soldiers included in the sample, indicating that they were relatively consistent with data on the underlying population. Finally, I survey existing historical height studies on Brazil, arguing that the military sample offers the best glimpse of height trends at the national and regional levels. Now, our discussion with shift to the procedures used to estimate the historical height trends. In Chapter 4, I will trace the temporal trends and regional patters in height based on the AHEX sample.

Appendix

Table 3.6

AHEX Sample Statistics											
Panel A: AHEX Data	(All figures are numbers of cases by cohort of birth)										
Birth Cohort	1850	1860	1870	1880	1890	1900	1910	1920	1930	1940	1950
Total Cases	433	1002	1092	2117	2389	1933	1609	2725	1044	663	1334
Recruitment Decade	1870	1880	1890	1900	1920	1930	1940	1950	1960	1970	1980
Total Cases	209	1128	1037	2042	2825	1947	1644	2896	1121	655	1276
Skin Color											
Black	79	176	180	300	212	163	66	175	123	41	31
Mixed	218	504	595	1,107	1,358	975	506	1048	491	376	835
White	113	297	310	632	689	775	1,048	1502	445	246	465
Amerindian	21	37	42	109	80	12	2	0	0	0	0
Occupational Category											
Unskilled	373	901	914	1,766	1,588	790	476	715	291	336	726
Semiskilled	13	24	41	67	266	481	265	567	154	22	75
Skill/manual	71	99	156	251	456	548	685	1039	429	203	283
Whitecollar	1	5	16	43	103	102	186	409	184	106	253
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	1766	801	359	573
South	35	135	164	480	333	331	631	464	19	4	17

Figure 3.10 indicates that the distribution of heights in the military follows a normal distribution. The figure also reveals that the sample was bi-modal, that is, we can identify two points of central tendency; while the mode in Regimes 1 and 2 was approximately 160 cm, the mode of Regime 3 is 162 centimeters. Intriguingly, it was not the shift from impressment to conscription (moving from Regime 1 to Regime 2) that divides the two modes between the subseries.

Figure 3.10

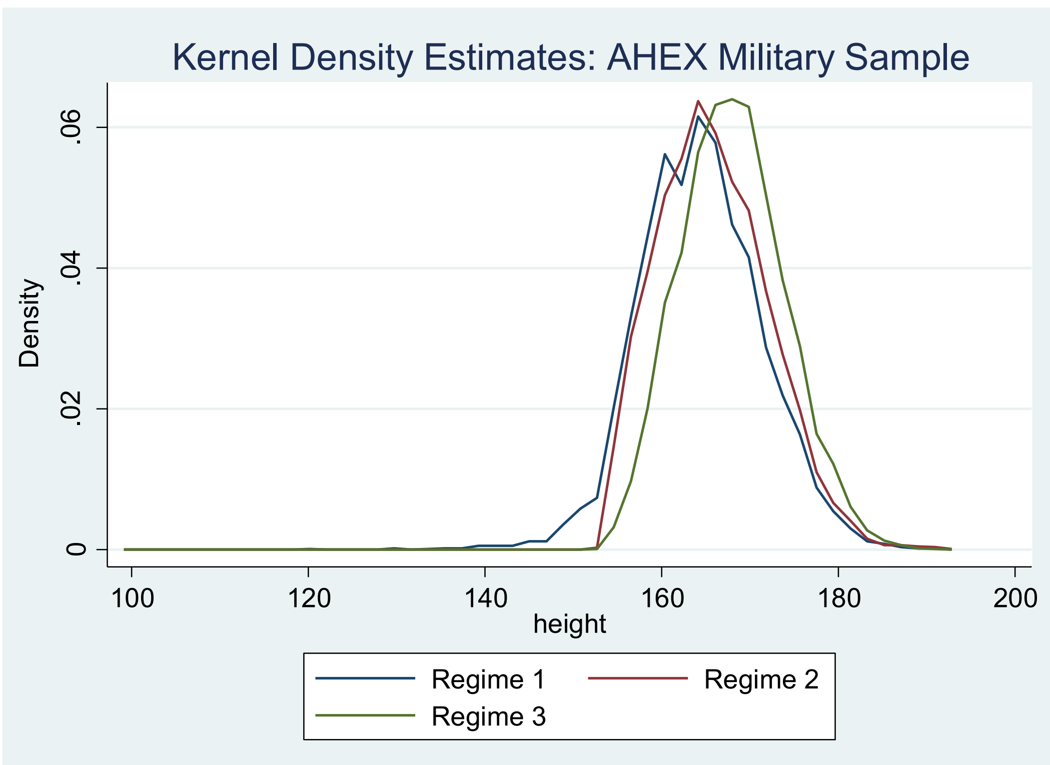


Table 3.7

Regional Distribution: AHEX Sample by Recruitment Period										
Region	North		Northeast		Center West		Southeast		South	
Recruit Decade	N	%	N	%	N	%	N	%	N	%
1870	8	3.83	150	71.77	5	2.39	22	10.53	23	11.0
1880	10	.89	687	60.9	54	4.79	228	20.21	148	13.12
1890	11	1.06	606	58.44	100	9.64	187	18.03	127	12.25
1900	46	2.25	1,257	61.56	47	2.3	245	12	438	21.45
1910	628	22.23	1,695	60	6	.21	159	5.63	328	11.61
1920	55	2.82	865	44.43	25	1.28	599	30.77	314	16.13
1930	11	.67	216	13.14	33	2.01	672	40.88	653	39.72
1940	70	2.42	436	15.06	78	2.69	1,855	64.05	453	15.64
1950	12	1.07	176	15.7	46	4.1	842	75.11	17	1.52
1960	9	1.37	143	21.83	151	23.05	346	52.82	2	.31
1970	10	.78	283	22.18	433	33.93	525	41.14	18	1.41

Skin Color

As noted in the text, there were some 23 descriptors of skin color reported in the AHEX documentation. What follows is a list of the reported descriptors, their English translations, and the racial category assigned to match census records.[143] One can observe that the majority of the skin color descriptors were easily categorized; however, a number of descriptors could have fallen into two racial categories. For example, those reported to be of *morena escura* (dark mulatto) skin, could have been placed in either the mixed-race

143 The original documentation denotes "Pêle: ____". Since *pele* is a feminine noun, the majority of the descriptors were in the feminine form (even though they apply to males).

or the black category. Similarly, those listed as being *bronzeada* or *trigueira* could have fallen in the mixed-race or white category.

Table 3.8

Reported Skincolor	English Translation	Category	Freq.	Percent	Cum.
No Color	N/A	N/A	206	1.21	1.23
Acabocla	Mix White/Indian	Amerindian	2	0.01	1.23
Agrisalhada	Greyed	Mixed-Race	1	0.01	1.23
Amarela	Yellow	(Excluded)	1	0.01	1.24
Indiaca	Amerindian	Amerindian	143	0.84	2.08
Asiatica	Asian	(Excluded)	1	0.01	2.09
Branca	White	White	6,600	38.94	41.03
Bronzeada	Tanned	White	4	0.03	41.05
Cabocla	Mix White/Indian	Amerindian	154	0.92	41.97
Cabra	(lit.) Goat	Mixed-Race	3	0.02	41.99
Cafuza	Indian/black	Amerindian	8	0.06	42.05
Clara	White	White	17	0.1	42.15
Caboclo	Amerindian	Amerindian	7	0.04	42.19
Escuro	Dark	Mixed-Race	15	0.09	42.28
Fula	Bronze-colored	Black	29	0.17	42.45
Mestiça	White/Black (Mulatto)	Mixed-Race	29	0.17	42.62
Morena	Mulatto	Mixed-Race	4,185	24.69	67.31
Morena Clara	Light Mulatto	Mixed-Race	184	1.09	68.4
Morena Escura	Dark Mulatto	Black	105	0.62	69.02
Parda	Mulatto	Mixed-Race	3,217	18.98	88
Pardo Clara	Light Mulatto	Mixed-Race	287	1.69	89.69
Pardo Escura	Dark Mulatto	Black	194	1.14	90.84
Preta	Black	Black	1,553	9.15	99.99
Trigueira	Wheat-Colored	White	15	.1	100
Total			16,948	100	

Chapter 4. Temporal Height Trends of the AHEX Dataset

Introduction

In 1878, the prominent public official and medical physician, José Pereira do Rêgo, the Barão do Lavradio, published "On Mortality in Rio de Janeiro City, Particularly that of Children" in which he decried the poor public health conditions in the city and linked the high number of infant deaths and stillbirths to hygienic factors. The Barão states: "These conditions [the high number of infant deaths] are subjected to, or rather depend on, infractions against the laws of hygiene, by consequence of vices contracted in our habits and customs that perturb our physical development."[144] According to the author, it was ignorance regarding the basic concepts of hygiene that was most damning for the health of Brazilian children, and consequently the future of the nation.

One of the many examples of practitioners of medicine calling for public health reform in late-nineteenth-century Brazil, the 1878 publication of the Barão do Lavradio brought child-rearing practices and the education of women to the fore. Most certainly a man of his time, the Baron issued an attack on women for hiring wet-nurses in order to enjoy 'high society' opera and theater performances. Despite his patriarchal criticism, Pereira do Rêgo was correct to lament the practice of hired wet-nursing (for reasons more clearly elucidated in Chapter 5). In late-nineteenth-century Brazil, women became seen

[144] José Pereira do Rêgo, *Apontamentos sobre a mortalidade da cidade do Rio de Janeiro particularmente das crianças.* (Rio de Janeiro: Typographia Nacional, 1878), 30-31.

as the reproducers of modernity.[145] The Barão do Lavradio viewed women as "the main element of man's regeneration in the civilized world," but in order to fulfill that mission, he saw it was crucial to give women proper instruction in sanitary and hygienic protocols.[146] As we shall see, beginning in the 1890s, the *hygienista* (hygienist) movement ushered in a number of innovations in public services oriented towards bettering the health of the populace, while the *maternalista* (maternalist) movement introduced institutions aimed at improving child-rearing practices for mothers in need. Relying on human height data drawn from the AHEX sample, this chapter traces trends in height from the military dataset in order to observe if the state impetus to modernize Brazil in the late-nineteenth and early-twentieth centuries translated into clear improvements in health.

Infant and child mortality statistics, when collected with accuracy, shed light on hygienic conditions. In the 1870s, the Barão do Lavradio indicates that over 30 percent of children died before the age of 4. Concrete statistics on the number of total births and the number of deaths in the first year of life for nineteenth-century Rio de Janeiro are sparse. Just over a decade after the Baron's 1878 publication, in 1890 the earliest continuous series on infant mortality in the city suggests a rate 302.9 deaths before one year of age per 1,000 live births.[147] In other words, for approximately every three children born, one would perish before the age of one. Elsewhere in Brazil, the situation was not particularly more sanguine; in 1897 official statistics indicate that the infant mortality rate in Bahia

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145 Ana Paula Vosne Martins, *Visões do feminino: a medicina da mulher nos séculos XIX e XX* (Rio de Janeiro: Editora Fiocruz, 2004).

146 Ibid., 32.

147 Brasil, *Annuário de estatística demographo-sanitária, 1915-1916* (Rio de Janeiro: Tipografia Nacional, 1926), 95-97.

was 215.4, while in Rio Grande do Norte the figure had reached a dismal 346.6 per 1,000 births.[148] By 1915, the rate of infant mortality in Rio de Janeiro had dropped to 139.3, pointing to a substantial improvement in health conditions.[149] Using anthropometric evidence, this dissertation will examine the extent to which such an improvement in public health was generalized throughout Brazil.

The objective of this chapter is to estimate and analyze the stature trends of the Brazilian population from 1850 to 1950. One component of this analysis will include direct scrutiny of sample-selection biases and confounding factors. As discussed in Chapter 2, data on stature shed light on early-age health conditions by capturing the interaction between nutritional intake and the demands made on those nutrients by homeostasis, defense of infections, and work expenditure.[150] At the beginning of the study period, average height in the Brazilian military sample was approximately 164 cm in 1850; at the end of the period, by 1950 average stature had climbed to 168.5 cm. As we shall see in Chapter 6, since the majority of the upsurge in stature took place between 1895 and 1915, I argue that the contemporaneous effects of an improved disease environment and increased real income accounted for the observed upsurge in stature. Internal migration to healthier areas of Brazil also accounted for a portion of the increase.

The discussion proceeds as follows: Section 4.1 charts the trends in height of the military data sample, presenting sample means and baseline regression results. Subsequently, Section 4.2 discusses sample-selection bias and alternative hypotheses that

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148 See Chapter 1.

149 Brasil, *Annuário de estatística demographo-sanitária,* 95-7.

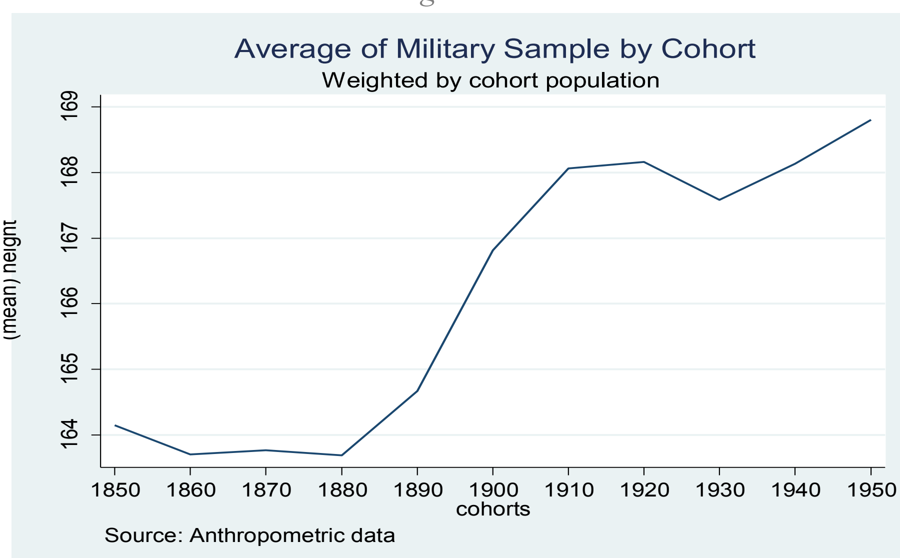
150 Richard Steckel, "Strategic Ideas in the Rise of the New Anthropometric History and Their Implications for Interdisciplinary Research." The Journal of Economic History, Vol. 58, No. 3 (Sep., 1998), 803-821.

could confound the analysis of the height trends. Section 4.3 estimates height trends of geographical subgroups, namely by rural-urban provenance and region of origin. Section 4.4 concludes.

4.1. Longitudinal Trends: Military Sample

This subsection sketches the trends in height of the military data sample, beginning with an elucidation of the mean height by cohort of birth. Then, it examines the mean height of racial subgroups. Figure 4.1 examines the mean height of soldiers 21 years of age or older.

Figure 4.1

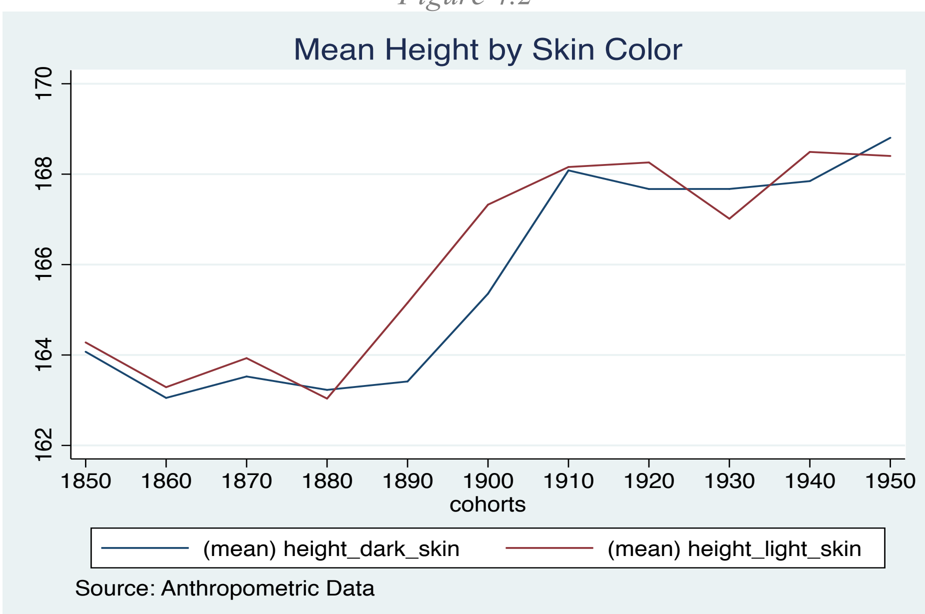


Average stature of the sample remained relatively stagnant in the mid-nineteenth century, while there was a considerable increase in the means of approximately 4.5 cm beginning in the birth cohort of 1880 and ending in the 1910s. Heights stagnated through the 1920s until declining slightly in the 1930s. In the 1940s and 1950s, there is also a marked upward trend in stature, though the increase is less pronounced than that observed in the

1880-1910 period. Below we shall see how well these raw sample means stack up with regression results, which take into account observable characteristics of the soldiers in order to produce more reliable estimates.

Historians of Brazil have long been interested in racial differences with respect to health and living standards (as seen in Chapter 1). A particular strength of the military dataset is its ability to retrieve data across the national territory before and after the 1888 abolition of slavery. Although there is no direct way of knowing if soldiers had been slaves themselves or were the children of enslaved parents, an analysis of anthropometric trends amongst racial subpopulations of the military sample may shed light on the allocation of health between ethnic groups before and during the transition to wage-based labor. Figure 4.2 depicts the average height of soldiers by skin color.

Figure 4.2



For simplicity, I have collapsed the numerous skin color classifications into two categories, light and dark skin. Dark- and light-skinned soldiers display relatively little difference in height, except for the period associated with the greatest increase in stature from roughly 1880 to 1910, when soldiers with light skin display a small height advantage (of about 2 cm). This may seem to contradict popular assumptions about the health status of Brazilians of African descent in the nineteenth and early-twentieth centuries; however, 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).[151] Using the available census data, Adamo highlights the racial differentials in infant mortality rates in Rio de Janeiro between 1890 and 1940 (reproduced in Table 4.1 below).

Table 4.1

Infant Mortality Rates by Race in Rio de Janeiro			
Year	White	Mulatto	Black
1890	397.2	407.3	496.6
1937	56.6	134.0	270.9
1938	65.3	148.7	379.0
1939	72.9	144.3	317.0
1940	123.4	240.7	204.4

Source: Adamo, "The Broken Promise," 93.

Two features of the table stand out: 1) there was both an absolute decline in infant mortality across all racial groups between 1890 and 1940, and 2) compared to whites, there was a higher number of infant deaths amongst the nonwhite population. In 1890, nearly one half of all black infants died before one year of age. This lends credence to the notion that the adult height of dark-skinned male soldiers displayed in Figure 4.2 is upwardly-biased. Selection issues cause the difference in adult height between white and

151 Carlos Bozzoli, Angus S. Deaton, and Climent Quintana-Domeque. "Child mortality, income and adult height." No. w12966. National Bureau of Economic Research, 2007.

nonwhite soldiers to be smaller than one might assume, since those dark-skinned individuals that survived to adulthood were likely also taller, yielding a skewed distribution of heights. One plausible data source to examine racial health differentials with more accuracy would be disaggregated figures on birthweight. Such figures do not exist in Brazil until the 1930s. What is more, given the small ratio of hospital to home births characteristic of the era, birthweight data would likely present selection issues as well.

Despite this glimpse of racial health inequalities, it is intriguing to note the racial composition of soldiers rejected from service for health reasons and insufficient stature. The same military physician discussed at the beginning of Chapter 2, Arthur Lobo da Silva, conducted a study on the physical traits of Brazilian soldiers, "A anthropologia no exército Brasileiro." His analysis included 38,657 soldiers that answered the draft call and presented themselves for medical examination between 1922 and 1923. Of the total examined, 8,282 were rejected for health reasons or for insufficient stature. Lobo da Silva found that only 71 percent of those classified as white were acceptable for service, while the acceptance rates for black and mixed-race soldiers were 80 percent and 81 percent, respectively. Military historian Frank McCann suggests that the higher acceptance rate for the black and mixed-race recruits could be explained by the concentration of those ethnicities in the North and Northeast, where medical examiners were perhaps less well-trained and less cautious in their diagnoses. However, considering only those rejected for having statures lower than the MHR is illuminating. Of the 575 rejected for insufficient height, 280 (48.7 percent) were white, 45 (7.8 percent) were black, and 239 (41.6

percent) were mixed-race.[152] This leads to the conclusion that selection issues varying by race do not affect the AHEX sample.

These trend estimates give us a general idea about the evolution of mean stature within the military series itself. Regression analyses will account for individual characteristics, such as region, younger ages, and occupation, in order to produce height estimates more representative of the Brazilian nation as a whole.

Regressions Results: Military sample

The sample means presented above pertaining to individuals inducted after the 1916 universal conscription law will be somewhat upwardly biased due to the minimum height requirement (MHR) set at 154 cm in 1916 and 155 cm in 1936. Since a number of soldiers were rejected from service for having insufficient height, taking solely the sample means during periods subjected to an MHR will overstate the average. Thus, the analysis of the military sample for soldiers inducted after 1916 requires statistical methods that account for the shortfall in the distribution of heights.[153] Truncated maximum-likelihood (ML) regressions provide reliable methods to estimate population heights from deficient samples.[154] In sum, 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 an MHR

152 Frank D McCann, *Soldados Da Pátria: História Do Exército Brasileiro, 1889-1937*, trans. Laura Teixeira Motta (Rio de Janeiro: Biblioteca do Exército Editora, 2009), 296.

153 OLS regressions assume a standard normal distribution. In essence, using OLS regressions for the recruitment regimes in which a MHR existed would bias the coefficients for our variable of interest upwards. In practical terms, consider a case in which a researcher seeks to determine the average GPA of students at a university, but he or she can only obtain data on student athletes. If participation in a sports team requires a student to maintain a minimum GPA of 2.0, for example, by not accounting for the shortfall of the distribution, this method would bias the calculated average GPA upwards.

154 Komlos, "How to (And How Not To) Analyze Deficient Height Samples: An Introduction."

existed, regressions using truncated maximum-likelihood methods to account for truncation provide reliable estimates.[155]

What differentiates regression analysis from simply calculating the raw means of each cohort is the ability to account for observable characteristics. Using OLS and truncated ML regressions as appropriate, I estimate regressions of the following form:

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

In order to capture temporal trends in health, birth cohort is the explanatory variable of interest, while dichotomous "dummy" variables for skin color, occupation, age, and region control for individual observable characteristics that may bias the estimates. With these control variables, the regressions are able to capture the birth-cohort effects above and beyond all other factors in the model. For example, 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).[156] In addition, as we noted in Chapter 2, individuals tend to reach adult height around the age of 21. Thus, by adding in variables for ages 20 and younger, we are able to distill the young-age effects from the coefficients for birth cohort.

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[155] I perform these regressions with Stata's *truncreg* command.

[156] Though not supplied here, using state dummy variables does not change the results. Furthermore, since migration within states was much cheaper and physically easier than between regions, I am likely to avoid much of the bias associated with inter-state migration. On this point, see López-Alonso, *Measuring Up*.

Prior to proceeding with regression analyses, I examined the distribution of heights for normality (as discussed in the Chapter 3) and for the presence of univariate outliers, i.e., data points that exhibit a degree of deviation from the distribution that would lead us to assume they are irregular or idiosyncratic in some way. General definitions of mild outliers are those data points that lie outside the interval defined by 1.5x the inter-quartile range. Extreme outliers are those cases that lie outside the interval defined by 3x the inter-quartile range. In this instance, I removed extreme univariate outliers from the sample.

In the OLS and truncated ML regressions, the sample is broken down by recruitment regime.[157] Height was regressed on dichotomous 'dummy' variables for birth cohort, skin color, occupation, young age, and region, and the results from this baseline regression model can be found in Table 4.3 in the Appendix of this chapter. In the regression tables, the main variables of interest are the decadal birth cohorts, and adding the constant term plus the birth cohort coefficients yields the average height of soldiers born in each respective decade.

In interpreting the regression results, of most concern are the magnitude of the coefficients and their statistical significance. In its most basic form, a linear regression measures the strength of an independent variable (also known as a "predictor" or an "explanatory" variable) to predict variations in a dependent variable (also known as the "response" or "outcome" variable). In essence, regressions implement statistical formulas to calculate the parameters (i.e., the slope or magnitude of the effect and the intercept) of a "line of best fit" that will run as close as possible to the observed data points. If results

[157] Recruitment regime periods are identified in Chapter 3. Regime 1= incorporated before 1916. Regime 2=incorporated 1916-1936. Regime 3= incorporated after 1936.

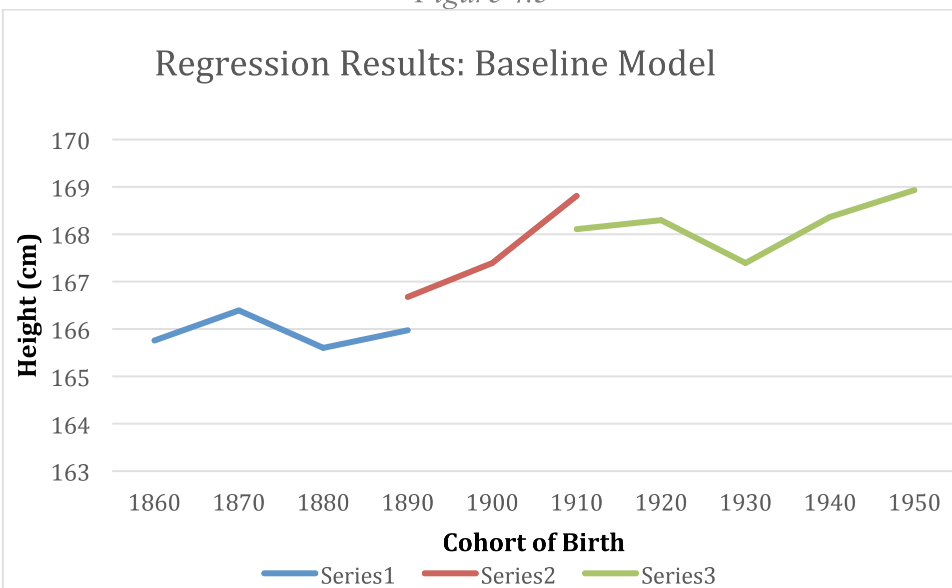
show that the line of best fit for a given variable does not provide a statistically better prediction of height than simply using the mean, we would conclude that the explanatory variable in question does not reliably predict height.

In addition to the magnitude of the regression coefficients, the statistical significance of a particular variable is also useful information. The p-value of a regression coefficient determines the level of certainty with which we can assert that the explanatory variable contributed to the variance in the outcome variable beyond chance levels. For example, if a coefficient is statistically significant at the 5 percent level ($p < .05$), this implies that there are fewer than 5 chances in 100 that we would observe a coefficient of the same magnitude or larger if the explanatory variable actually had no real effect on the outcome variable. Social scientists generally accept $p < .05$ as a threshold for determining that an effect was not spurious (that is, likely due to something other than chance), although p-values of less than 0.1 are generally accepted by economic historians as marginally significant.

Figure 4.3 provides a visual depiction of the regression coefficients for the decadal birth cohorts. The birth cohort coefficients indicate that average stature hovered around 166 cm from 1860 to 1880. In 1880, stature reached a low of 165.6 cm. By 1910, the estimate from Regime 2 indicates that stature increased to 168.8 cm, denoting an average decadal gain of roughly 1.1 cm.

The variables on race, occupation, and region help assess the evolution of inequalities in health over time (see Table 4.3 in this chapter's Appendix). In Regime 1, the black dummy returns a value of 0.520 with respect to whites, an interesting finding given 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 Regime 2, where the black dummy coefficient is estimated at -0.508, while the mixed-race dummy coefficient is -1.3 compared to whites. The racial dummy coefficients are not statistically significant and are of little magnitude in Regime 3. Amerindian soldiers were consistently shorter in Regimes 1 and 2. Although the statistical significance disappears in Regime 3, this is likely because there were few soldiers coded as Amerindian in that recruitment period.

Figure 4.3



Source: Fitted values taken from Appendix Table 4.3.

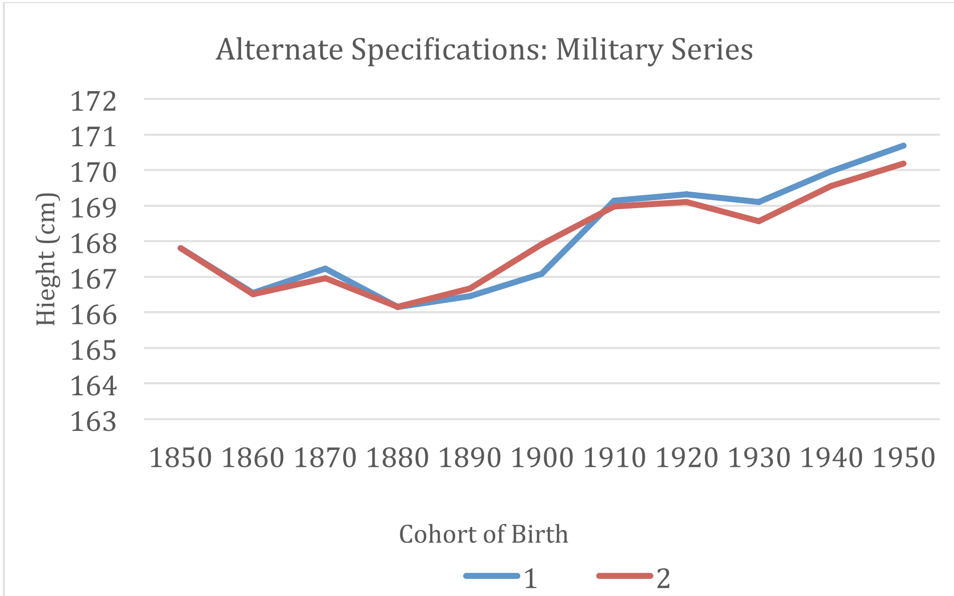
The results presented in Table 4.3 support the idea that a portion of the dramatic increase seen in the sample means in Figure 4.1 was explained by the transfer of the population concentration from the northern to the southern regions of Brazil (in which there were more salubrious conditions). Highly statistically significant across all of the specifications in Table 4.3 are the region dummy variables. In Regime 1, compared to those from the South, soldiers from the North display a height disadvantage of 3.75 cm, while those from the Northeast were 2.9 cm shorter. In Regime 2, the coefficient of the

North decreases to -6.076, while that of the Northeast decreases to -3.78. Regime 3 indicates some regional convergence in stature; however, compared to those from the South, soldiers from the Northeast were still 2.144 cm shorter, and those from the North display inferior heights by 2.682 cm. From 1850 through 1950, the regression results suggest that soldiers from the North and Northeast were systematically shorter. Chapter 6 will provide an exhaustive discussion of these regional height patterns.

The results also present interesting findings in terms of occupational class differentials in heights. White-collar professionals were 2.252 cm taller than unskilled soldiers in Regime 1, but this premium declined over time. In Regime 3, the white-collar dummy returns a value of only 0.885 cm, indicating that social inequalities in height diminished over the first half of the twentieth century. While fascinating, the convergence between occupational classes is likely overstated by the military sample. Also, the young-age dummies lose statistical significance in the later cohorts, indicating these individuals reached full adult height sooner in life.

One model of alternate specifications considers the possibility that occupation class is an intermediate variable in the case of the long-term evolution of heights. Since occupational classes evolve as a country develops, and our main concern is tracking changes in height over time, including occupation class explanatory variables could lead to over-adjusting the data. In order to avoid this possibility, one set of regressions drops the occupational class dummy variables and uses weights for occupational class taken from the national censuses instead (plotted line 2 in Figure 4.4). However, the use of occupational weights appears to alter the results minimally.

Figure 4.4



4.2 Addressing Sample-Selection Bias and Potential Confounders

Sample-selection bias has received recent attention in the historical heights literature, and this section addresses concerns with sample selection bias using a diagnostic test proposed by Bodenhorn, Guinnane, and Mroz, whose work has chipped away at the credibility of historical height samples derived from military records and other sources.[158] I also consider potential factors that might confound the trend results presented in the preceding section. One source of concern stems from the 1916 shift in recruitment practices, while another potential issue arises with the influx of European immigrants in the late-19th and early-20th centuries.

Conceptualizing the military and the labor market at perfect substitutes, Bodenhorn et al. implement diagnostic tests to detect selection biases in historical height

[158] H. Bodenhorn, T. W. Guinnane, and T. A. Mroz, "Problems of Sample-Selection Bias in the Historical Heights Literature: A Theoretical and Econometric Analysis," *Economic Growth Center Discussion Paper*, no. No. 1023 (2013); H. Bodenhorn, T. W. Guinnane, and T. A. Mroz, "Sample-Selection Bias and the 'Industrialization Puzzle,'" *NBER Working Paper*, no. 21249 (June 2015).

datasets. Within the military context, the major concern is that varying economic conditions from year to year can change the type of individual that enlists in military service. For example, during economic downturns with high unemployment, one might expect for individuals of higher socio-economic status to enlist in the military than would do under more "normal" economic conditions. Given that humans reach terminal adult height by age 23, the logic behind the tests identifies soldiers born in the same year that enlisted at different ages (provided that the cases included pertain to those that had reached full adult height). This implies that the heights of men born in a particular year who joined the army at age 23 will not deviate from those born in the same year who enlisted at age 24. If the diagnostic procedures identify any difference in average height between soldiers of differing ages born in the same year, this indicates that the appeal to enlist when a given cohort reached age 23 was different from the same when the cohort reached 24. Evidence of heights differing between ages for those born in the same year would indicate that labor market alternatives influenced the decision to enlist the army, thus implying that the measured heights in the sample varied with economic cycles.

As discussed in Chapter 3, until 1916, the Brazilian military predominantly filled its ranks by means of impressment. The low pay, inability to honor contracts, and the poor treatment of soldiers caused the public to view army service with disdain. For a fee, membership in the National Guard provided immunity from conscription, and this avenue allowed many elite and middle-class Brazilians to avoid direct military service. A full-scale draft lottery was implemented in 1916. While most of the exemptions from service remained unchanged, the shift from traditional recruitment to universal conscription presents a formidable obstacle to assessing the secular trend in stature in Brazil based on the AHEX sample. The concern here is that the conscription law implied a greater number of recruits from the higher-income groups. Applying the sample-selection diagnostic methodology devised by Bodenhorn and co-authors, we shall see if the conscription law induced sample-selection bias.

Table 4.2

Sample-Selection Diagnostics: Regression Summaries		
Model 1 154cm, Ages 22-27	F-stat: 5 age dummies P-Value DF	0.55 **0.739** (5, 5839)
Model 2 154cm, Ages 23-27	F-stat: 4 age dummies P-Value DF	0.83 **0.5043** (4, 3363)
Model 3 155cm, Ages 22-27	F-stat: 5 age dummies P-Value DF	0.65 **0.6577** (5, 5795)
Model 4 155cm, Ages 23-27	F-stat: 4 age dummies P-Value DF	1.03 **0.3879** (5, 5795)
Model 5 154cm, Ages 22-27	F-stat: 5 age dummies P-Value DF	0.38 **0.8635** (5, 4156)
Model 6 154cm, Ages 23-27	F-stat: 4 age dummies P-Value DF	0.42 **0.7936** (4, 2324)
Full regressions reported in Table 4.8 of this chapter's Appendix.		

Full regressions for the selection diagnostics are presented in Table 4.8 in the Appendix and summarized in Table 4.2. The F-tests used to identify if the regression coefficients for ages are equal to zero indicate that varying economic conditions per recruitment year did not influence the type of individual who enlisted in the military. This is important evidence since inferences about changes in height over time have been called into question based on the detection of sample-selection biases in other instances. At least in the case of Brazil, military records have not met their demise in the historical heights literature.

In addition to potential selection issues emanating from time-varying recruitment practices, one additional source of concern stems from a wave of immigration to Brazil that was also roughly contemporaneous with the increase in height shown in Figure 4.3. As noted in Chapter 1, in the late-nineteenth century policy makers became concerned with the possibilities of finding low-cost labor in the wake of the abolition of slavery and sought to promote immigration to Brazil. Officially immigration was primarily sponsored from Italy, but swathes of German, Austrian, Spanish, Ottoman, Russian, and French immigrants entered into Brazil as well.[159] Although immigrants generally did not serve in the military, many first-generation Brazilians did. Since European immigrants could have had heights superior to those of the average Brazilian, we might expect their children to display a height advantage. Figure 4.5 presents results from a set of adjusted regressions that modify the baseline model in order to consider the robustness of the results to this alternative hypotheses. The regression results are presented in Appendix Table 4.4.

In order to neutralize the bias originating from the transition from impressment to a more egalitarian service model, all of the specifications consider only those inducted after 1916. This requires the regression model to relax the assumption that the MHR was raised to 155 cm in 1936 in order to combine recruitment Regimes 2 and 3. Specifications 3 and 4 only include those soldiers with common surnames in an effort to exclude the children of many (non-Iberian) immigrants that entered into Brazil.[160] Since these recruits

[159] Total net immigration during the 1890-1940 interval was on the order of 3 million. See *Immigrants on the Land: Coffee and Society in São Paulo. 1886-1934.* (Chapel Hill: The University of North Carolina Press, 1980).

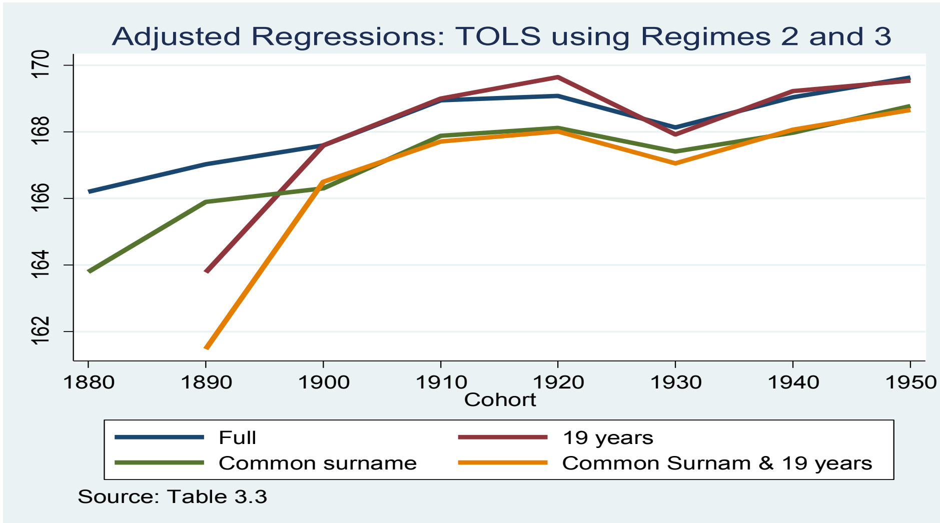
[160] Surnames were coded as uncommon if they fell below the 25th percentile of the cumulative distribution of all surnames reported. Unfortunately, since there is such a large convergence between Spanish and Portuguese surnames, it is difficult to distinguish between any recent Spanish arrivals in Brazil from any Brazilian-born individuals. Future research will use the US 1880 census to code the surnames found in the military sample by likely country or region of origin.

may have originated from families of immigrants with superior health and nutritional status upon entering Brazil, their heights are less indicative of trends within the Brazilian-born families.

In Figure 4.5, I present the fitted values for the birth cohort variables from these adjusted regressions. The full model (Specification 1) corroborates the time trends presented in the baseline model presented above; there was sustained growth in height from 1880 to 1910 of nearly 3 cm. Analyzing only soldiers of the median age (19 years) reveals an astounding height increase between 1890 and 1910. Specification 2, related to 19 year olds, verifies the upward trends illustrated in the baseline model. As we can observe in the cohort estimates, between 1890 and 1910 there was an increase in stature of 5.2 cm. The fact that 19-year-old soldiers showed a height disadvantage compared their elders before 1910 illustrates that stunting in Brazil was prevalent before the 1900s.

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 the effects from immigration. Specification 4 applies this method to soldiers with common surnames and of 19 years of age, and this strengthens the 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 these alternative hypotheses substantiates the upward trends in stature displayed in the baseline regressions. Consistent with what Baten et al and Monasterio and Signorini have found, immigration appears to have mattered little in determining the trajectory of Brazil's height trends.

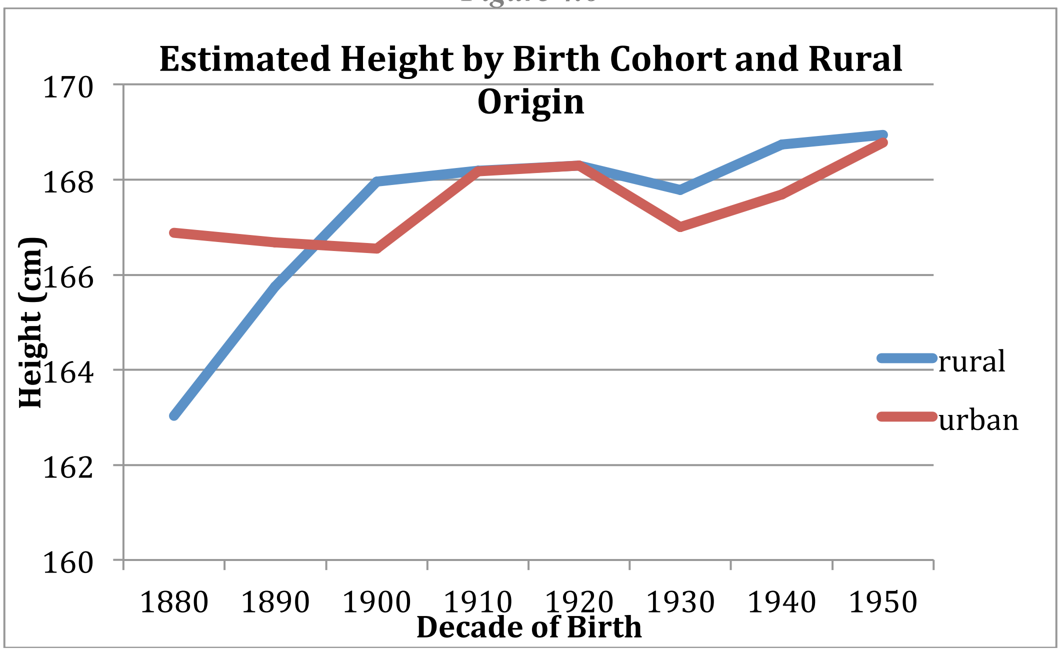
Figure 4.5



4.3. Heterogeneity in Height Trends

While the evidence on human height points to an improvement in health in aggregate terms during the final decade of the nineteenth century and first decade of the twentieth, our discussion merits a closer examination of the health consequences during the initial phase of industrialization (beginning circa 1870). As discussed in Chapter 2, many historical anthropometric studies have focused on the health consequences of industrialization, pointing to an 'urban height penalty' due to increased disease virulence in cities brought on by rapid urbanization. Since large cities received the majority of the epidemiological consequences associated with industrialization and urbanization, the regression presented in Appendix Table 4.5 employs a scheme to determine rural and urban provenance. While the AHEX documentation rarely incorporated the city of birth, I infer rural-urban origin based on several other characteristics. Soldiers coded as non-rural are those that were vaccinated for smallpox or previously had the disease prior to entering the military, or those that had a set of typically urban skills.[161] A visual depiction of the regression results can be found in Figure 4.6 below.[162]

Figure 4.6



Immediately evident are the inferior urban heights in the 1900 and convergence with rural heights in the 1910s and 1920s. This suggests that the health of urban residents worsened in the 1890s and 1900s, and that the public health interventions that began circa 1902 made great strides to improve health. We observe another decline in urban heights in the 1930s and 1940s, suggesting that the rural-urban gap re-emerged.

Overall, the height of urban residents was higher prior to roughly 1890. In Brazil, as in many other Latin American countries, there was a marked concentration of economic development within urban centers. Both of these periods of urban height gap--from 1890 to 1900 and from 1930-1940--are consistent with periods of migratory influx.

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161 Vaccination campaigns were largely centered in urban areas. See Hochman, *Era do Saneamento*, Ch. 3.

162 I have run the regressions for cohorts prior to 1890 as well. Interestingly, urban heights were superior from 1850 through 1890.

In the first instance, a wave of international migration began to surge from Europe to Brazil beginning in the late 1880s.[163] The historian Theresa Meade documents epidemics in malaria, yellow fever, smallpox, and influenza in the year of 1891--a year of significant immigration.[164]

During this period, the growth of the construction sector in major urban areas such as São Paulo and Rio de Janeiro failed to keep pace with the swathes of immigrants entering through Brazilian ports. Many likely cramped into squalid tenement buildings. The construction of a major highway linking the Rio de Janeiro-São Paulo industrial axis with the Northeast, coupled with the intensification of import-substitution industrialization, provoked another wave of migration to the Southeastern region circa 1940.[165] The worsening trend in urban heights in Brazil from 1890 to 1900 is in line with the estimates of Floud and Harris for England in the eighteenth and nineteenth centuries.[166]

In addition to considering rural-urban provenance, I consider region-specific temporal height trends. Historians have presumed that industrialization in the Southeast beginning circa 1870 caused inequalities between Brazilian regions. Since industrialization was chiefly concentrated in the Southeast, an analysis of the decadal cohort estimates by the main regions of Brazil will shed additional light on the health consequences associated with industrial growth. Further, the baseline regressions (Table

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163 Herbert S. Klein. "European and Asian migration to Brazil." In Robin Cohen (ed.) *The Cambridge Survey of World Migration* (Cambridge and New York: Cambridge University Press, 1995) 208-214.

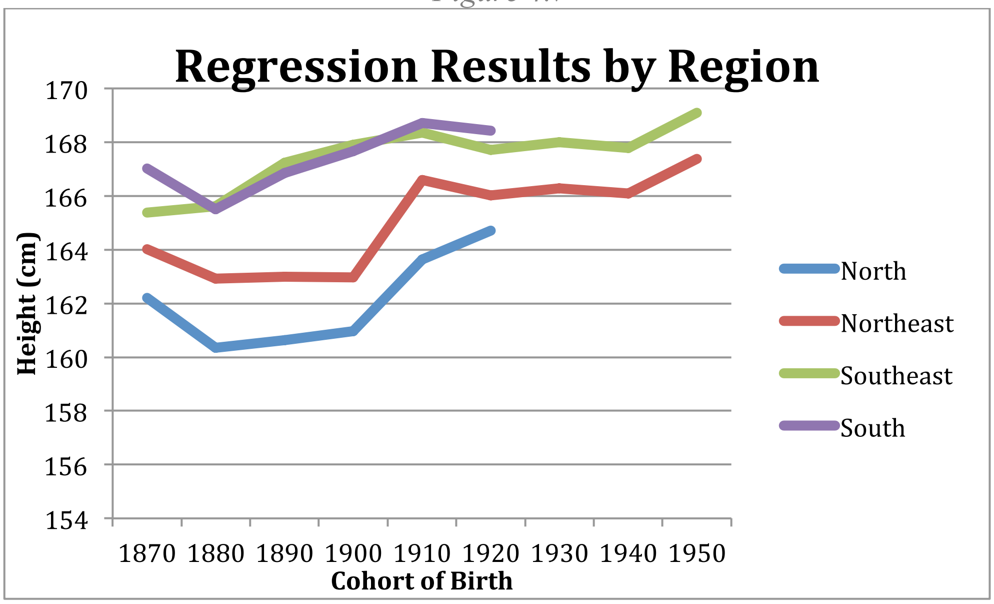
164 Theresa Meade, *Civilizing Rio*, 63.

165 Abreu, *Evolução Urbana*.

166 R. Floud and B. Harris, "Health, Height, and Welfare: Britain, 1700-1980," in R. Steckel and R. Floud, *Health and Welfare*, 91-126.

4.3) revealed highly statistically significant coefficient estimates for the region dummy variables, yet there were some inconsistencies across the specifications. Figure 4.7 below examines the evolution of stature trends by region for a closer look at regional height patterns.

Figure 4.7



Source: Table 4.6 in the Appendix.

While the South and Southeast were relatively equal after 1880, there is a clear persistent gap between the Northern and Southern regions throughout the study period.[167] The increase in stature in the South and Southeast predates that of the North and Northeast, reflecting real-income growth in the Southeast coffee sector, as well as the earlier implementation of health initiatives in these regions. Chapter 6 utilizes municipality-level climate data and other geographical variables to explore the underpinnings of these regional height differentials. The fact that heights did not decline in the Southeast (where industrialization was most concentrated) serves as further evidence that industrialization did not have a negative impact on stature. One outstanding finding in the region-specific

[167] The Center-West region displayed the highest volatility in the estimates, and for that matter it was excluded (as the N for this region was very small).

model is the dramatic height increase for soldiers hailing from the Northeast. In that region, heights increased from 162.9 cm in 1900 to 166.6 cm by 1910, an increase of more than 3.5 cm over one decadal birth cohort. Chapter 7 will hone in on the factors accounting for this unprecedented upsurge in stature in the Northeast.

4.4. Conclusion

This chapter has focused on the AHEX military dataset to trace the evolution of stature in Brazil from 1850 to 1950. Data on human height of soldiers illustrate substantial improvements in health associated with the first decades of the First Republic. Our discussion began with some of the public health concerns in Brazil in the late-nineteenth century. Then, it moved on to examine the mean stature of the military sample by birth cohort and by racial categories. At first glance, the sample means indicated an increase in stature of over 4 cm beginning in the 1890s. OLS and truncated ML regressions estimate the time trends and covariates of height, indicating that stature rose by over 3 cm between 1880 and 1910. While the individuals born in these cohorts likely benefited from improvements in health and sanitation during the First Republic, as well as the real income gains associated with industrialization and modernization, shifts in geographic patterns of the underlying population also explain a portion of the height increase.

Diagnostic tests designed to detect the presence of sample-selection bias and a series of robustness checks considering alternative hypotheses corroborate the upward trends depicted in the baseline regressions. Results from a sub-sample of soldiers above the age of 23 indicate that severe sample-selection bias is not present in the AHEX sample. Further, when the regressions are limited to only soldiers with common surnames in an effort to isolate potential immigrants, the cohort estimates reveal a four-centimeter 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. By limiting to age 19, this allows our analysis to isolate any time-varying effects of age on height, yielding a more insightful image of Brazilian health trends. Regardless of the adjusted specifications, we can safely argue that stature in Brazil increased by over 3 cm between 1880 and 1910.

This chapter also examined heterogeneous trends in heights amongst geographic sub-groups. I examine the health consequences of industrialization and urbanization by comparing the height trends of rural to urban soldiers. Given the data limitations, it would appear that industrialization did not lead to a decrease in stature as observed in other countries, although there is some evidence to suggest that urban penalties did emerge in times of migratory influx. Steckel encourages researchers to consider the timing of industrial growth and the onset of bacteriology when considering the health effects of industrialization. In Brazil, industrialization and policies informed by the germ theory of disease began relatively contemporaneously. Additionally, when disaggregated by region, the trends point to a long-standing height inequality between the southern and northern regions of the country. While heights in the South and Southeast began an upward trend in the late-nineteenth century, stature remained relatively stagnant in the Northeast until the 1910 cohort of birth, when I detect an increase in stature of over 3.5 cm. The discussion in Chapters 6 and 7 will contextualize these patterns and offer potential explanations for them. First, though, we shall now turn to the ancillary dataset of passport bearers.

Appendix

Table 4.3

Baseline Regressions: AHEX Sample			
VARIABLES	Regime 1 Height (cm)	Regime 2 Height (cm)	Regime 3 Height (cm)
cohort1850	ref.		
cohort1860	-1.045***		
cohort1870	-0.404		
cohort1880	-1.200***	ref.	
cohort1890	-0.822**	-0.526	
cohort1900		0.189	ref.
cohort1910		1.609**	-0.689
cohort1920			-0.511
cohort1930			-1.410***
cohort1940			-0.432
cohort1950			0.132
black	0.520*	-0.508	0.486
mixed	-0.128	-1.301***	-0.0691
white	ref.	ref.	ref.
amerindian	-0.956*	-1.939**	-5.784
unskilled	ref.	ref.	ref.
semiskilled	-0.248	1.117***	0.398*
skillmanual	0.695**	0.177	0.158
whitecollar	2.252***	1.619***	0.885***
age17	-3.930***	-0.620	-0.509
age18	-3.047***	-1.273**	-0.306
age19	-2.203***	0.929**	0.337
age20	-0.624*	-0.757*	-0.00485
north	-3.755***	-6.076***	-2.682***
south	ref.	ref.	ref.
southeast	-1.257***	0.419	-0.400*
centerwest	-3.145***	1.899*	-0.563*
northeast	-2.901***	-3.780***	-2.144***
Constant	166.8***	167.2***	168.8***
Observations	5,399	4,332	6,833
Sigma		6.328***	5.813***
R-squared	0.051		

*** p<0.01, ** p<0.05, *p<0.1

Source: Anthropometric data from the AHEX.

The omitted cohort for Regime 1 are soldiers born between 1850 and 1850; for Regime 2, born between 1880 and 1889; for Regime 3, 1900 and 1909. Reference categories for all specifications are white, unskilled soldiers from the South, of 21 years of age or older.

Table 4.4

Robustness: Post-Conscription Military Sample					
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***
age17	-0.845		-0.0992		
age18	-0.964***		-0.589		
age19	0.298		0.272		1.185
age20	-0.247		-0.200		-0.123
Constant	167.6***	167.6***	166.3***	166.5***	169.8***
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

Specification 1 refers to only recruitment regimes 2 & 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 category for this specification are rural soldiers from the south, 21 years of age or older, born between 1920 and 1929.

Table 4.5

Regressions by Rural-Urban Origin: AHEX Sample		
VARIABLES	Coef.	St. E.
cohort1880	-5.269**	(2.122)
cohort1890	-2.546***	(0.311)
cohort1900	-0.341	(0.344)
cohort1910	-0.117	(0.337)
cohort1920	ref.	
cohort1930	-0.518	(0.337)
cohort1940	0.435	(0.372)
cohort1950	0.646**	(0.311)
urban1880	3.854	(2.599)
urban1890	0.924***	(0.335)
urban1900	-1.409***	(0.362)
urban1910	-0.00938	(0.359)
urban1920	ref.	
urban1930	-0.775**	(0.393)
urban1940	-1.048**	(0.491)
urban1950	-0.172	(0.341)
south	0.583***	(0.188)
southeast	ref.	
centerwest	-0.202	(0.260)
northeast	-2.591***	(0.163)
north	-4.794***	(0.320)
Age Controls	Y	
Constant	168.3***	(0.143)
Sigma	6.007***	(0.0475)
Observations 11,197		

Table 4.6

Truncated ML Regressions by Region				
	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
age17	-0.534	-0.582	0.180	-3.506***
age18	1.110	-2.708***	-0.817*	-2.017***
age19	-0.522	0.255	-0.204	-0.145
age20	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				
All specifications pertain to TOLS regressions assuming a MHR of 154. Omitted categories are rural soldiers, 21 and older born between 1850 and 1869.				

Many of the variables collected for analyses do not serve as useful control variables. The table below interacts dummies for mode of entry, marital status, and literacy with cohort to examine for potential inequalities. While in some cohorts the variables are statistically significant, they do not point to any sustained patterns over time.

Table 4.7

Dep. Var.=Height *** p<0.01, ** p<0.05, * p<0.1					
Mode of Entry		Marital Status		Literacy	
cohort1850	ref.	cohort1850	ref.	cohort1850	ref.
cohort1860	-1.228***	cohort1860	-0.862**	cohort1860	-0.314
cohort1870	-0.602	cohort1870	-0.463	cohort1870	-1.24
cohort1880	-1.160***	cohort1880	-1.246***	cohort1880	-1.764
cohort1890	-1.036***	cohort1890	-1.106***	cohort1890	-0.5
cohort1900	1.137***	cohort1900	-0.691*	cohort1900	0.369
cohort1910	1.901***	cohort1910	1.682***	cohort1910	0.922
cohort1920	2.042***	cohort1920	2.008***	cohort1920	1.345
cohort1930	1.856***	cohort1930	1.792***	cohort1930	1.397
cohort1940	2.732***	cohort1940	2.623***	cohort1940	1.945
cohort1950	3.458***	cohort1950	3.407***	cohort1950	2.498*
volun_1850	ref.	married_1850	ref.	Illit_1850	ref.
volun_1860	0.609	married_1860	-0.225	illit_1860	1.324
volun_1870	0.851**	married_1870	0.997**	illit_1870	0.356
volun_1880	-0.395	married_1880	-1.084*	illit_1880	0.0212
volun_1890	-0.127	married_1890	0.566	illit_1890	-1.086***
volun_1900	-4.804***	married_1900	2.505***	illit_1900	-2.835***
volun_1910	-0.806	married_1910	0.627	illit_1910	0.935*
volun_1920	0.756	married_1920	-0.84	illit_1920	-0.826*
volun_1930	0.433	married_1930	2.753	illit_1930	-1.533*
volun_1940	0.23	married_1940	-2.092	illit_1940	-0.043
volun_1950	3.190***	married_1950	-3.193	illit_1950	0.142
black	0.269	black	0.252	black	0.547**
mixed	-0.425***	mixed	-0.411***	mixed	-0.552***
amerindian	-0.0851	amerindian	-0.157	amerindian	-0.308
age17	-2.683***	age17	-2.554***	age17	-2.183***
age18	-2.501***	age18	-2.572***	age18	-2.434***
age19	-1.026***	age19	-1.003***	age19	-0.616**
age20	-0.937***	age20	-0.946***	age20	-0.384
age21	-0.473**	age21	-0.461**	age21	-0.335
age22	-0.364**	age22	-0.392**	age22	-0.560***
north	-4.703***	north	-4.747***	north	-5.831***
southeast	-0.862***	southeast	-0.843***	southeast	-0.928***
centerwest	-0.557**	centerwest	-0.595**	centerwest	-0.491
northeast	-2.823***	northeast	-3.021***	northeast	-3.715***
Constant	167.5***	Constant	167.6***	Constant	168.2***
Sigma	6.203***	Sigma	6.234***	Sigma	6.352***
N	15,581	N	15,581	N	10,798

Table 4.8

Selection Diagnostic Regressions

	(1)	(2)	(3)	(4)	(5)
VARIABLES	height	height	height	height	height
1850b.yob	Ref.	Ref.	Ref.	Ref.	Ref.
	(0)	(0)	(0)	(0)	(0)
1851.yob	0.101	-1.424	0.0495	-1.523	0.0232
	(3.304)	(3.978)	(3.228)	(3.881)	(3.163)
1852.yob	-2.627	-4.119	-2.696	-4.199	-2.706
	(3.399)	(3.805)	(3.321)	(3.712)	(3.254)
1853.yob	-3.118	-3.067	-3.186	-3.141	-3.186
	(3.651)	(4.104)	(3.567)	(4.004)	(3.494)
1854.yob	-0.947	-1.784	-1.025	-1.860	-1.060
	(3.466)	(3.808)	(3.387)	(3.715)	(3.318)
1855.yob	-2.229	-2.045	-2.284	-2.116	-2.306
	(3.266)	(3.701)	(3.191)	(3.610)	(3.126)
1856.yob	-0.419	-2.006	0.633	-0.378	0.617
	(3.303)	(3.881)	(3.270)	(3.879)	(3.203)
1857.yob	-1.531	-2.327	-0.929	-1.715	-0.947
	(3.186)	(3.558)	(3.136)	(3.491)	(3.073)
1858.yob	-1.406	-2.211	-1.084	-1.883	-1.083
	(3.072)	(3.458)	(3.012)	(3.382)	(2.951)
1859.yob	-0.485	-1.208	-0.511	-1.229	0.426
	(2.993)	(3.406)	(2.924)	(3.323)	(2.880)
1860.yob	-2.349	-2.760	-2.407	-2.820	-2.210
	(2.978)	(3.394)	(2.909)	(3.311)	(2.854)
1861.yob	-1.436	-3.233	-0.886	-2.963	-0.906
	(2.991)	(3.430)	(2.932)	(3.352)	(2.873)
1862.yob	-1.357	-3.130	-0.497	-2.094	-0.279
	(2.944)	(3.422)	(2.887)	(3.359)	(2.831)
1863.yob	-2.341	-3.054	-2.415	-3.133	-1.782
	(2.967)	(3.382)	(2.899)	(3.299)	(2.850)
1864.yob	-3.383	-4.272	-2.710	-3.476	-2.535
	(2.946)	(3.364)	(2.888)	(3.294)	(2.832)
1865.yob	-1.937	-2.569	-1.800	-2.416	-1.496
	(2.925)	(3.338)	(2.859)	(3.258)	(2.805)
1866.yob	-0.533	-0.240	0.177	0.221	0.157
	(3.012)	(3.453)	(2.956)	(3.377)	(2.896)
1867.yob	-1.843	-1.796	-1.356	-1.404	-1.125
	(2.971)	(3.444)	(2.910)	(3.368)	(2.855)
1868.yob	-1.780	0.732	-1.782	0.675	-1.794
	(2.991)	(3.877)	(2.923)	(3.782)	(2.863)
1869.yob	-1.174	-0.913	-0.215	-0.963	-0.208
	(3.301)	(3.745)	(3.269)	(3.654)	(3.202)
1870.yob	-1.548	-3.805	-1.640	-3.932	-0.831
	(3.269)	(3.752)	(3.194)	(3.660)	(3.164)
1871.yob	-2.130	-2.912	-2.208	-3.000	-2.230
	(3.208)	(3.630)	(3.135)	(3.542)	(3.071)
1872.yob	-2.614	-2.794	-2.703	-2.896	-2.444

	(3.020)	(3.446)	(2.950)	(3.362)	(2.897)
1873.yob	-0.886	-1.780	-0.597	-1.436	-0.598
	(2.999)	(3.420)	(2.935)	(3.342)	(2.876)
1874.yob	-1.433	-2.032	-1.487	-2.089	-1.215
	(3.005)	(3.420)	(2.936)	(3.336)	(2.881)
1875.yob	-3.469	-5.001	-2.745	-4.073	-2.501
	(2.995)	(3.443)	(2.942)	(3.385)	(2.888)
1876.yob	-2.683	-2.773	-2.133	-1.905	-1.526
	(2.952)	(3.395)	(2.892)	(3.327)	(2.843)
1877.yob	-3.029	-4.686	-2.859	-4.448	-2.871
	(2.962)	(3.426)	(2.897)	(3.349)	(2.838)
1878.yob	-0.0635	-0.586	-0.128	-0.663	0.361
	(2.960)	(3.386)	(2.892)	(3.303)	(2.840)
1879.yob	-2.834	-2.748	-2.149	-2.249	-1.604
	(2.939)	(3.382)	(2.881)	(3.307)	(2.831)
1880.yob	-3.246	-3.890	-3.208	-3.843	-2.927
	(2.907)	(3.325)	(2.842)	(3.245)	(2.788)
1881.yob	-1.425	-2.313	-1.320	-2.159	-0.804
	(2.903)	(3.339)	(2.838)	(3.259)	(2.784)
1882.yob	-0.835	-2.594	-0.639	-2.323	-0.322
	(2.890)	(3.325)	(2.825)	(3.246)	(2.769)
1883.yob	-1.910	-2.668	-1.750	-2.488	-1.564
	(2.895)	(3.311)	(2.831)	(3.232)	(2.775)
1884.yob	-1.884	-2.315	-1.675	-1.997	-1.260
	(2.879)	(3.308)	(2.815)	(3.230)	(2.760)
1885.yob	-1.931	-2.706	-1.654	-2.419	-1.111
	(2.876)	(3.307)	(2.812)	(3.228)	(2.758)
1886.yob	-2.796	-3.576	-2.665	-3.412	-2.262
	(2.886)	(3.307)	(2.821)	(3.228)	(2.767)
1887.yob	-2.185	-2.788	-1.618	-2.078	-1.367
	(2.880)	(3.310)	(2.818)	(3.234)	(2.762)
1888.yob	-2.282	-3.015	-1.765	-2.632	-1.549
	(2.874)	(3.300)	(2.811)	(3.222)	(2.755)
1889.yob	-2.241	-3.548	-1.736	-3.188	-1.531
	(2.874)	(3.326)	(2.811)	(3.249)	(2.755)
1890.yob	-3.526	-3.635	-3.066	-3.031	-2.902
	(2.895)	(3.365)	(2.832)	(3.291)	(2.776)
1891.yob	-2.783	-4.211	-2.672	-4.303	-2.235
	(2.932)	(3.409)	(2.866)	(3.326)	(2.813)
1892.yob	-2.043	-3.277	-1.077	-2.276	-0.542
	(2.927)	(3.359)	(2.870)	(3.290)	(2.818)
1893.yob	-4.476	-5.059	-4.031	-4.653	-3.551
	(2.905)	(3.319)	(2.844)	(3.243)	(2.793)
1894.yob	-3.037	-3.862	-2.964	-3.777	-2.536
	(2.907)	(3.314)	(2.842)	(3.234)	(2.789)
1895.yob	-4.057	-4.524	-3.991	-4.435	-3.807
	(2.874)	(3.299)	(2.809)	(3.220)	(2.753)
1896.yob	-2.895	-3.908	-2.534	-3.705	-2.321
	(2.869)	(3.396)	(2.805)	(3.318)	(2.749)
1897.yob	-2.878	-2.554	-2.478	-2.111	-2.175

	(2.844)	(3.361)	(2.780)	(3.284)	(2.724)
1898.yob	-2.996	-4.031	-2.222	-3.028	-1.939
	(2.892)	(3.363)	(2.832)	(3.296)	(2.777)
1899.yob	1.591	-1.783	1.673	-1.836	1.736
	(2.866)	(3.358)	(2.801)	(3.276)	(2.744)
1900.yob	-1.457	-3.113	-1.287	-1.921	-1.226
	(2.878)	(3.534)	(2.813)	(3.487)	(2.756)
1901.yob	-2.109	-3.442	-1.840	-3.238	-1.721
	(2.916)	(3.392)	(2.852)	(3.313)	(2.796)
1902.yob	1.398	0.955	1.392	0.898	1.544
	(2.871)	(3.347)	(2.805)	(3.265)	(2.749)
1903.yob	-4.849	-2.590	-3.778	-2.725	-2.945
	(2.965)	(3.706)	(2.919)	(3.615)	(2.879)
1904.yob	1.357	0.898	1.305	0.831	1.467
	(2.918)	(3.352)	(2.851)	(3.270)	(2.795)
1905.yob	1.723	3.000	1.675	2.925	1.638
	(3.115)	(3.636)	(3.044)	(3.548)	(2.982)
1906.yob	1.382	0.709	1.318	0.637	1.291
	(2.905)	(3.324)	(2.839)	(3.243)	(2.781)
1907.yob	2.340	1.500	2.453	1.605	2.739
	(2.896)	(3.305)	(2.830)	(3.225)	(2.774)
1908.yob	0.0723	-1.963	0.0376	-2.026	0.429
	(3.039)	(3.495)	(2.970)	(3.409)	(2.917)
1909.yob	-0.472	2.277	-0.461	2.261	-0.477
	(2.972)	(4.587)	(2.904)	(4.475)	(2.845)
1911.yob	3.508	2.667	3.450	2.605	3.429
	(2.983)	(3.380)	(2.915)	(3.297)	(2.856)
1912.yob	4.160	3.470	4.076	3.368	5.108*
	(3.185)	(3.603)	(3.112)	(3.515)	(3.071)
1913.yob	1.358	0.313	1.440	0.385	1.428
	(2.880)	(3.293)	(2.814)	(3.213)	(2.757)
1914.yob	1.618	1.406	1.792	1.348	1.776
	(2.867)	(3.505)	(2.802)	(3.420)	(2.745)
1915.yob	1.206	0.0406	1.320	0.152	1.294
	(2.906)	(3.318)	(2.840)	(3.238)	(2.783)
1916.yob	0.841	-0.557	0.893	-0.475	1.046
	(2.873)	(3.323)	(2.807)	(3.243)	(2.751)
1917.yob	-0.0886	-0.958	-0.135	-1.018	-0.00422
	(2.902)	(3.330)	(2.836)	(3.249)	(2.779)
1918.yob	1.278	0.394	1.380	0.511	1.516
	(2.896)	(3.307)	(2.830)	(3.227)	(2.773)
1919.yob	0.684	-0.328	0.641	-0.385	0.761
	(2.864)	(3.282)	(2.799)	(3.202)	(2.742)
1920.yob	0.862	0.00519	0.907	0.0720	0.950
	(2.858)	(3.294)	(2.793)	(3.214)	(2.736)
1921.yob	0.0587	-0.861	0.248	-0.922	0.320
	(2.876)	(3.437)	(2.811)	(3.353)	(2.755)
1922.yob	0.385	1.052	0.459	1.224	0.668
	(2.865)	(3.319)	(2.800)	(3.239)	(2.744)
1923.yob	0.990	-1.648	1.238	-1.379	1.382

	(2.869)	(3.403)	(2.804)	(3.325)	(2.748)
1924.yob	1.384	0.555	1.347	0.499	1.366
	(2.849)	(3.264)	(2.783)	(3.185)	(2.727)
1925.yob	0.135	-0.405	0.135	-0.477	0.350
	(2.951)	(3.749)	(2.883)	(3.657)	(2.827)
1926.yob	-1.036	-9.073	-1.028	-9.129	0.109
	(3.401)	(6.487)	(3.323)	(6.329)	(3.317)
1927.yob	4.988	4.143	4.900	4.068	4.871
	(6.325)	(6.490)	(6.180)	(6.332)	(6.054)
1928.yob	-5.226	-6.073	-5.265	-6.129	-5.280
	(6.322)	(6.487)	(6.177)	(6.329)	(6.051)
1929.yob	-2.154	-7.768	-2.151	-7.782	-2.160
	(3.793)	(5.126)	(3.706)	(5.001)	(3.630)
1930.yob	3.533	4.188	3.529	4.190	3.526
	(3.649)	(4.289)	(3.565)	(4.184)	(3.493)
1931.yob	-1.030	-1.871	-1.107	-1.954	-1.120
	(3.795)	(4.106)	(3.708)	(4.005)	(3.633)
1932.yob	2.202	1.315	2.128	1.238	2.106
	(3.400)	(3.806)	(3.322)	(3.713)	(3.255)
1933.yob	7.423*	6.618	7.340**	6.541	7.321**
	(3.794)	(4.104)	(3.707)	(4.004)	(3.632)
1934.yob	2.997	1.617	2.960	1.554	2.938
	(3.208)	(3.807)	(3.134)	(3.714)	(3.071)
1935.yob	0.903	0.383	0.876	0.343	0.864
	(3.793)	(4.291)	(3.706)	(4.186)	(3.630)
1936.yob	1.773	3.981	1.761	3.920	1.744
	(3.347)	(4.294)	(3.270)	(4.189)	(3.204)
1937.yob	-1.512	0.143	-1.532	0.0679	-1.553
	(4.320)	(6.490)	(4.221)	(6.332)	(4.135)
1938.yob	-3.862		-3.849		-2.265
	(3.796)		(3.709)		(3.830)
1939.yob	-0.179	0.143	-0.199	0.0679	-0.219
	(3.652)	(5.134)	(3.569)	(5.009)	(3.496)
1940.yob	3.597	2.797	3.576	2.769	3.571
	(4.318)	(4.586)	(4.219)	(4.474)	(4.133)
1941.yob	-3.253	-9.573*	-3.253	-9.629*	-3.268
	(3.465)	(5.131)	(3.385)	(5.005)	(3.317)
1942.yob	-1.950	-4.808	-1.986	-4.904	-1.998
	(3.651)	(4.590)	(3.568)	(4.477)	(3.495)
1943.yob	-0.929		-0.915		-0.931
	(4.321)		(4.222)		(4.136)
1944.yob	-0.551	0.143	-0.545	0.0679	-0.562
	(3.236)	(6.490)	(3.162)	(6.332)	(3.098)
1945.yob	-0.226	-1.073	-0.265	-1.129	-0.280
	(6.322)	(6.487)	(6.177)	(6.329)	(6.051)
1946.yob	0.747	0.927	0.747	0.871	0.732
	(4.000)	(6.487)	(3.908)	(6.329)	(3.829)
1950.yob	-2.012	-2.857	-2.100	-2.932	-2.129
	(4.902)	(5.134)	(4.790)	(5.009)	(4.692)
1951.yob	3.448	2.657	3.410	2.627	3.401

	(3.793)	(4.102)	(3.706)	(4.002)	(3.630)
1952.yob	-0.381	-3.465	-0.393	-3.531	-0.411
	(3.652)	(5.130)	(3.568)	(5.005)	(3.495)
1953.yob	-2.167	-0.465	-2.205	-0.531	-2.225
	(4.320)	(5.130)	(4.221)	(5.005)	(4.135)
1954.yob	6.059*	3.071	6.050*	3.002	6.031*
	(3.304)	(4.591)	(3.228)	(4.479)	(3.163)
1955o.yob					
age23	-0.0362		0.0164		0.0154
	(0.227)		(0.225)		(0.223)
age24	-0.250	-0.216	-0.148	-0.197	-0.135
	(0.272)	(0.289)	(0.270)	(0.286)	(0.268)
age25	-0.507	-0.610*	-0.505	-0.694**	-0.537*
	(0.315)	(0.337)	(0.311)	(0.333)	(0.310)
age26	0.199	0.203	0.392	0.323	0.368
	(0.366)	(0.391)	(0.364)	(0.388)	(0.363)
age27	0.169	0.168	0.305	0.217	0.361
	(0.408)	(0.430)	(0.406)	(0.428)	(0.405)
1955.yob	2.238		2.251		2.235
	(4.898)		(4.786)		(4.689)
Constant	167.3***	168.1***	167.2***	168.1***	167.3***
	(2.832)	(3.250)	(2.767)	(3.170)	(2.711)
Observations	5,781	3,382	5,636	3,297	5,499
R-squared	0.113	0.122	0.105	0.115	0.100

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Chapter 5. Trends in Height of Passport Bearers

Introduction

In the late-nineteenth century, worldwide improvements in transportation implied a general reduction in the ticket price for travel on steam boat vessels. As a result, there was a large increase in trans-oceanic travel. In Brazil, the resulting increase in passengers traveling on steam vessels implied both a radical increase in immigration from abroad and greater geographic mobility for domestic travelers. At the same time, regulations governing maritime travel stipulated that every individual boarding a ship, either for domestic or international travel, was required to carry a passport. Passport records for both foreign-born and Brazilian travelers are housed in the *Arquivo Nacional* (AN, National Archive) in Rio de Janeiro. As discussed previously, passport records are one source used by historical heights researchers to capture persons belonging to the upper socio-economic statuses of society. In this chapter, I consider the results from ancillary dataset of passport bearers. I argue that the sample of passport bearers offers important insights into the higher socio-economic statuses of the Brazilian population; however, this sample does not accurately capture national or regional height trends of the underlying population.

5.1 The passports records and sampling methods.

A sample of 6,025 passport bearers serves as an ancillary source to reflect trends in health and living standards of the higher echelons of Brazilian society. The GIFI section of the AN contains two series of passport records from the Rio de Janeiro Civil

Police—the authority responsible for maritime travel from the city's port. Anthropometric historians that have used passport records in the past have suggested that they pertain to the middle class and elite sectors of society. Surely, it would be improper to assume that all of the travelers were elite since most steamers had middle-class and steerage sections. However, since passport bearers were either commissioned to travel for work or had the disposable income to purchase a ticket for leisure, it is plausible to assume they were more well-to-do than the military recruits.

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, with less frequency, her) supporting documentation. Most passports noted a driver's license or ID card used as a supporting document for the issuance of the passport. 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). 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.”

Passport records indicate the date of issuance, date of birth, place of birth, place of residence, destination of travel, occupation, and physical characteristics (height, eye color, hair color, and skin color) of the applicant. The passport bearers were mainly white. Perhaps revealing some racial prejudice, most of the passport records did not include a description of skin color, but rather a check mark. For the purposes of this study, I assumed that the passport bearers were white unless indicated otherwise.

The sample of passport bearers pertains to 5,590 Brazilian and 873 foreign-born individuals travelling from the port of Rio de Janeiro between 1912 and 1937. All individuals that were between the ages of 18 and 50 were included in the sample. The age cut off ends at age 50 because individuals tend to lose stature after that age. After age 50 humans experience a substantial decline in stature due to postural loss—the vertebrae become more compacted and the cartilage in the knees begins to deteriorate.

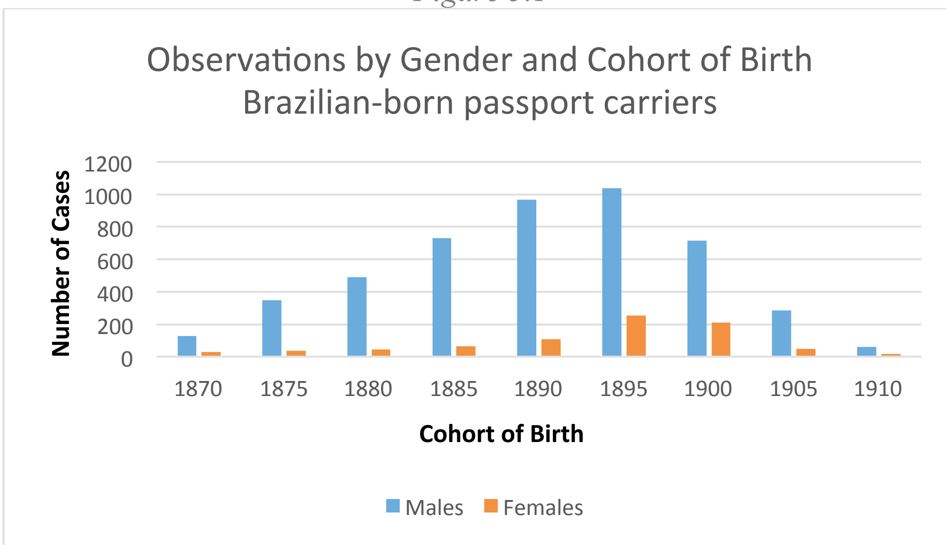
The largest obstacle to creating a random sample of the passport records was posed by the sporadic underreporting of heights. As a general rule, all passport records with height information were recorded. Prior to 1927, I recorded every other record without a valid height measurement. When reporting was even sparser in the 1930s, I recorded every passport record with a valid height measurement and every third record without a valid height measurement. In total, I recorded over 8,000 records in the passports sample prior to cleaning the data and discarding unusable observations. The absence of a valid height measurement was uncorrelated with any available control variables except for age. Children under the age of 12 systematically lacked height measurements.

5.2. Sample statistics of the passports records

Who were the passport bearers, and how do they compare to the individuals included in the military sample? This section focuses on the native-born Brazilians, while

5.4 discusses immigrants. In total, 5,590 observations of native-born Brazilians remained in the sample after the requisite cleaning. Of those native-born Brazilians, 4,775 observations pertain to males, and 815 to females. Figure 5.1 delineates the sample by gender and five-year birth cohorts.

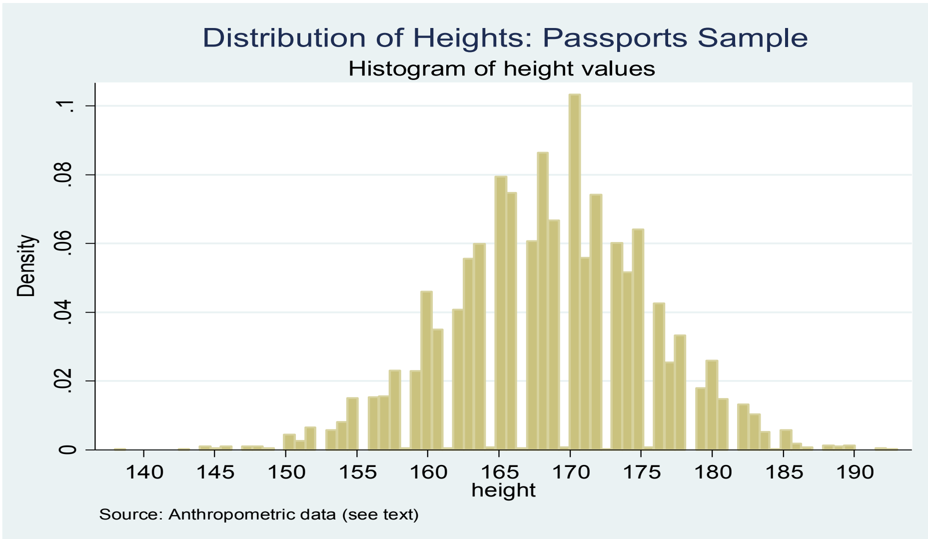
Figure 5.1



Immediately evident is the lack of female subjects included in the sample. As noted previously, in many travel years the female travelers were not assigned a precise value for their stature, but rather they were assigned a categorical description. As such documents cannot be used for a heights series, I chose to exclude them from the sample. Due to the limited number of observations containing heights of females, my discussion of the summary statistics of the sample focuses predominantly on the Brazilian-born males.

Similar to the military files, there is little information about how, when, and where the passport bearers were measured. The distinct method of reporting heights in the passport series becomes clear when we examine the distribution of heights in graphical representation (see Figure 5.2). Our primary glance at the distribution of the passport sample reveals severe heaping and some divergence from standard normal bell-curve shape.

Figure 5.2



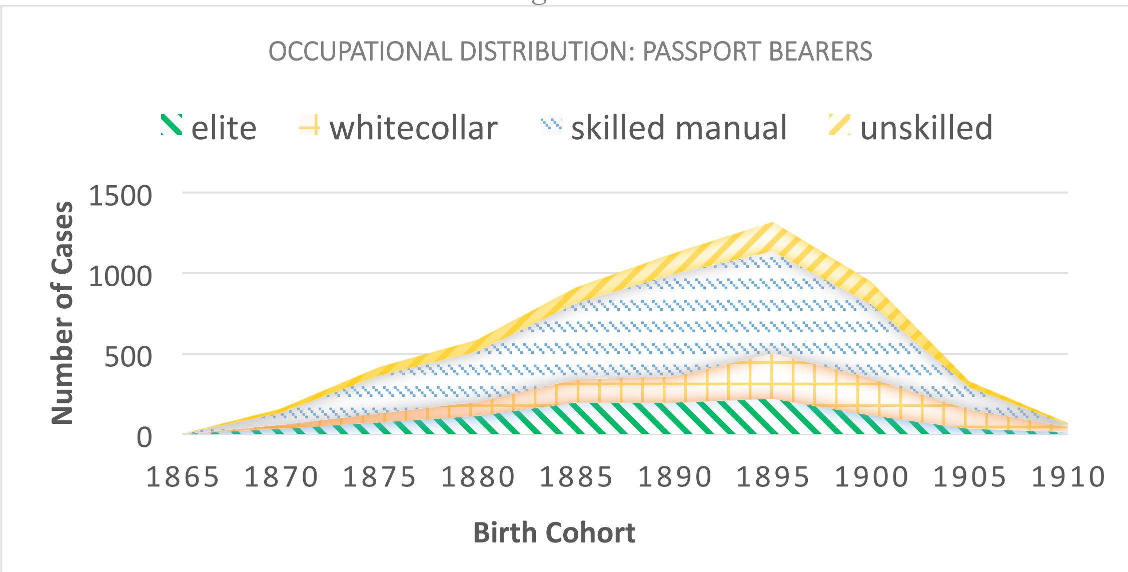
We can observe some evidence of heaping since height values appear to be clustered around particular values. Measurements ending in 0s or 5s appear more abundantly than we might assume given the dearth of height values in the range between those digits. For example, as one can observe, many passport bearers listed 160 as their height, yet there are relatively few measurements of 157 or 162. The presence of heaping may suggest that height values were not always measured by the scrivener/officer but were at times self-reported.

The evidence of some height heaping does complicate, the interpretation of the passports sample, but it does not invalidate the claims we can make about general trends. As discussed previously, anthropometric historians have dealt with such issues in the past, and there is a consensus that rounding is self-neutralizing. Steckel notes that, while heaping affects many data sources, "simulations of several cases suggest that these adverse aspects were relatively minor for estimates of sample means, primarily because their effects are largely self-cancelling."[168] That is, if rounding was fairly uniform over the interval, roughly the same amount of individuals rounded their heights up relative to those that round their heights down. As a result, the bias from rounding tends to be neutral. Despite the apparent rounding errors, the sample of passports provides important insights into the health status of relatively well-off Brazilians.

Viewed in comparison to the military sample, the sample of passports captures the more prosperous members of Brazilian society. As we have seen, in the late-nineteenth and early-twentieth centuries, the vast majority of soldiers held unskilled jobs (or none at all) prior to entering the military. In contrast, the passports pertain largely to skilled-manual, white-collar and elite Brazilians. Figure 5.3 charts the number of cases by occupational category for Brazilian-born men. As we can see, travelers with skilled-manual professions accounted for the bulk of the sample, accounting for roughly 50 percent across all cohorts. Unskilled laborers played a minor role in the passports sample.

[168] Steckel, Richard H. "Heights and health in the United States, 1710–1950." *Stature, Living Standards, and Economic Development* (1994): 155-156.

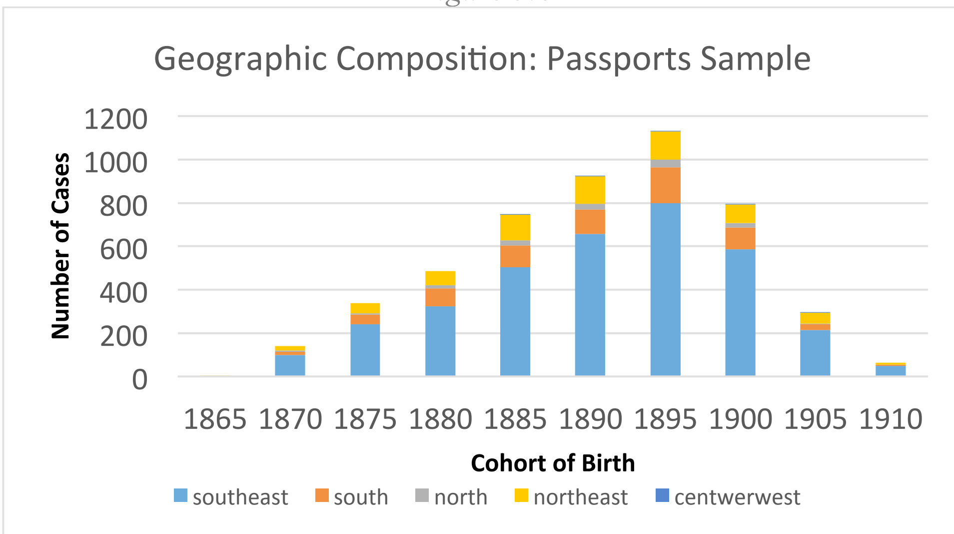
Figure 5.3



Rather than the increase in skill-level observed in military data series, in the passports data there is relative consistency in the occupational distribution over time. For those born between 1870 and 1895, the elite and white-collar travelers represented 19 and 15 percent of the sample, respectively. From the interval from 1895 to 1910, elite travelers accounted for only 15 percent of the sample, while white-collar individuals pertained to 20 percent. Despite the minor fluctuation in the elite and white-collar share of the passports sample, unskilled laborers represented between 11 and 13 percent 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, are evident in the regional composition of the sample of passports (see Figure 5.4). Since the passport records pertain to individuals travelling from the port of Rio de Janeiro, 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.

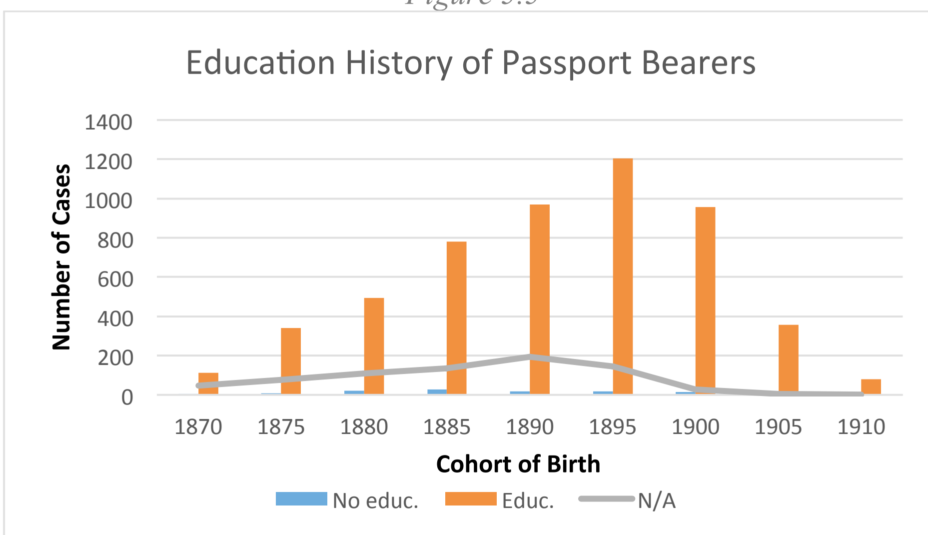
Figure 5.4



Those born in the port city of the *Districto Federal* (Rio de Janeiro city) were the most abundant, totaling 1,906 observations. 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 embarkation for these passport bearers differed vastly from their place of birth, I assume that all of the Northern and Northeasterners were migrants, and therefore they likely yield upwardly-biased stature estimates for those regions. In some cases, however, the passport records additionally provide a place of residence, allowing to distinguish between those that lived in Rio de Janeiro and those that were there in transit. Accounting for less than 1 percent of the sample, individuals from the Center-West region were too few to analyze separately.

In contrast to the military sample, in general the passports sample consists of literate individuals. One common technique used to infer the literacy status of an individual involves inspecting the related document for a personal signature.[169] This method would not aptly capture the literacy status of the passport bearers since a number of records were not signed. I noted a number of passports from physicians or engineers without signatures during data collection. Fortunately, the passport records also solicited the educational history of the traveler. A section of the passports asked if the person had any primary schooling. Responses were limited to "yes", "superior", or "without education." Figure 5.5 displays the literacy status of the passport bearers by five-year cohort of birth.

Figure 5.5



5.3. Trends in Height: Passport Bearers

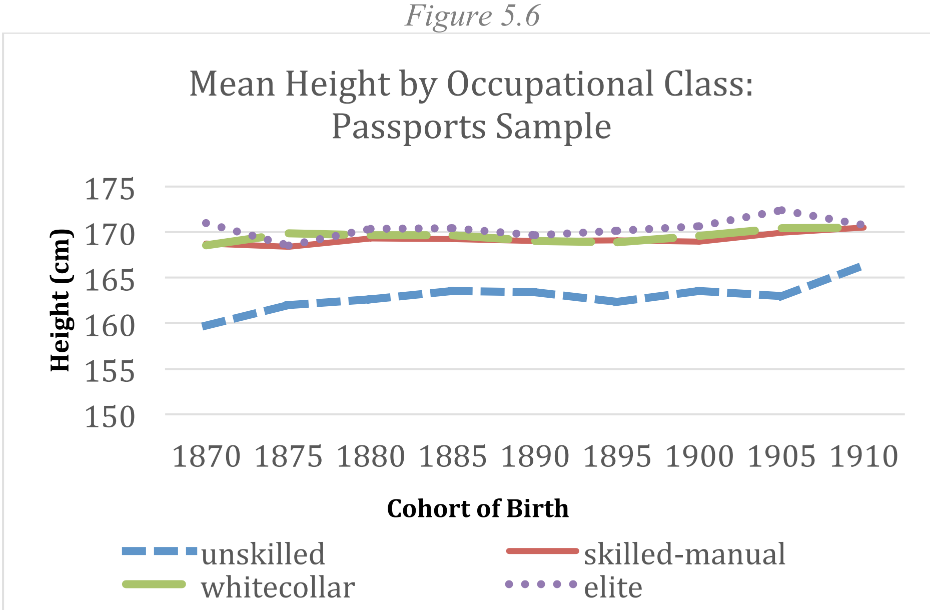
Time Trends

As noted above, 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. Figure 5.6 demonstrates the mean height of Brazilian-born males over the age of

169 See Lopez-Alonso, *Measuring Up.*

20 by occupational category. Contrary to the trends observed in the military sample, the skilled-manual, white-collar, and elite men displayed superior heights over the entire interval covered by the sample, and they present little upward trend. Contrastingly, between 1880 and 1910, the heights of unskilled passport bearers increased from 162.6 to 166.3, denoting a decadal gain of 1.2 cm—roughly equivalent to the estimates based on the military series for the same period. The upward trend amongst the unskilled is more accentuated in the 1905 and 1910 birth cohorts. This could suggest that the public health and sanitation campaigns undertaken in Rio de Janeiro had a positive impact on health.

Figure 5.6

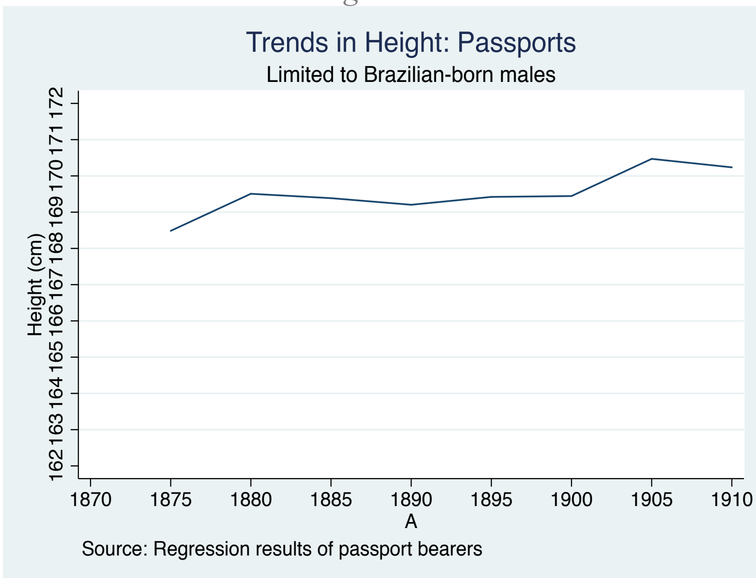


In order to account for observable characteristics, I also rely on regression analyses in order to estimate height trends from the passport records. OLS regressions are appropriate for use in the passports sample since there was no minimum height requirement for travel. Table 5.2 in the Appendix regresses height on dummies for cohort of birth, occupation, young ages, and region.[170] Figure 5.7 below presents the regression coefficients of males by birth cohort. 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 negative 6.16 cm, implying substantial inequality in height between unskilled and skilled/professional workers. Intriguingly, in Column 2, we can see that females did not display much of a disadvantage in height compared to males. (In fact, in most cohorts, the point estimates point to higher heights for females.) The persistence of hired wet-nursing might explain this stagnation in the heights of upper- and middle-class individuals. Common amongst these socio-economic groups until the 1930s, 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 lower-quality milk than they would have otherwise. Comparing the time trends of the passport bearers with those of the soldiers, we observe socioeconomic convergence in height during the study period. This is a rather interesting finding since income differentials normally widen in the initial phase of industrialization.[171] It would appear that the socioeconomic health gap improved with the efforts of the First Republican state (as will be discussed in Chapter 6).

170 I collapse the skilled, elite, and white-collar professions into one category for simplicity.

171 Simon Kuznets. "Economic growth and income inequality." *The American Economic Review* (1955): 1-28.

Figure 5.7



Geographic Heterogeneity

Given the long-standing regional height gap observed in Chapter 4, I explore geographic heterogeneity in the height trends of passport bearers by state. Here, we consider if the sample of passport bearers illuminates similar regional discrepancies. Table 5.1 reports summary statistics of height by state of birth of the passports sample. Although estimates of height derived from the military sample point to a radical regional discrepancy, the heights of passport bearers fail to reflect any regional inequities. Except for those from the state of Paraiba (n=18), individuals from all states had a mean height of roughly 168 centimeters, with some falling slightly below or slightly above that value. The epidemiological environment was likely more virulent in equatorial regions of Brazil; however, I speculate that the wealthier individuals included in the passports sample were able to afford better housing, nutrition, and enhanced measures of self-protection from disease.

Table 5.1

Mean Height of Passport Bearers by State							
Region	**State**	**Mean**	**Median**	**St. Dev.**	**Min**	**Max**	**N**
North	Amazonas	169.8833	170	6.917847	156	183	30
	Pará	169.3444	169.5	6.625048	155	185	90
Northeast	Alagoas	169.1078	170	6.085486	152	177	51
	Bahia	168.7563	169	7.222739	145	189	158
	Ceará	168.9419	168.5	5.811459	155	182	86
	Maranhão	168.8148	169	5.588705	159	181	27
	Paraíba	163.1667	162	8.445326	150	181	18
	Pernambuco	167.4242	168	7.016537	147	184	186
	Piauí	169.8462	168	4.947157	162	178	13
	Rio Grande do Norte	169.931	168	6.280247	157	181	29
	Sergipe	167.5862	169	6.63065	153	182	29
Center-West	Goiás	172.2857	172	4.715728	164	178	7
	Mato Grosso	167	168	8.304216	148	179	26
Southeast	DF	168.6694	169	6.893393	146	193	1767
	Espírito Santo	166.5122	166	7.067963	151	184	41
	Rio de Janeiro	168.5065	169	6.713993	146	186	538
	São Paulo	168.0891	168.75	7.431372	144	190	404
	Minas Gerais	169.3609	169	6.803366	146	190	471
South	Parana	168.6	169	5.928744	157	185	65
	Rio Grande do Sul	168.2105	168	7.340133	138	188	456
	Santa Catarina	168.2579	169	7.148078	152	183	95
Total		168.56	169	6.945706	138	193	4595

5.4. Foreign-Born Passport Bearers

In this section, I explore a sub-sample of foreign-born passport bearers. This analysis offers further evidence on the impact of immigration on Brazil's height trends.

The inability to determine whether the foreign-born individuals were repatriating or traveling for leisure constitutes one drawback to analyzing immigrants with this particular source of passport records. Although I did record the destination of the traveler, the passport records contain no information on return trips. In total, 873 foreign-born individuals entered into the passport sample. Of these foreign-born individuals, 862 were naturalized Brazilian citizens, and only 11 were non-naturalized. This suggests that the foreign-born individuals included in the sub-sample were likely intending to return to Brazil.[172] Of the total, 92 were females and 780 were males. In order to facilitate comparisons amongst sending countries, I limit this portion of the analysis to males only.

A graphical display of the height values disaggregated by the major sending countries appears in Figure 5.8. This type of diagram, the box-and-whisker plot (or simply, box plot), provides information on the variation of a given data series, displaying the minimum and maximum values and the overall spread of the data. The rectangular box represents the inter-quartile range (IQR)--the area within which 50 percent of the height values lie. The dark horizontal line inside the box is the median, or the point at which half of all values fall above and half below. The summary statistics denoting values by quartiles appear in Table 5.3 in the Appendix to this chapter. For purposes of comparison, the first column in Figure 5.8 corresponds to Brazilian-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).[173] When

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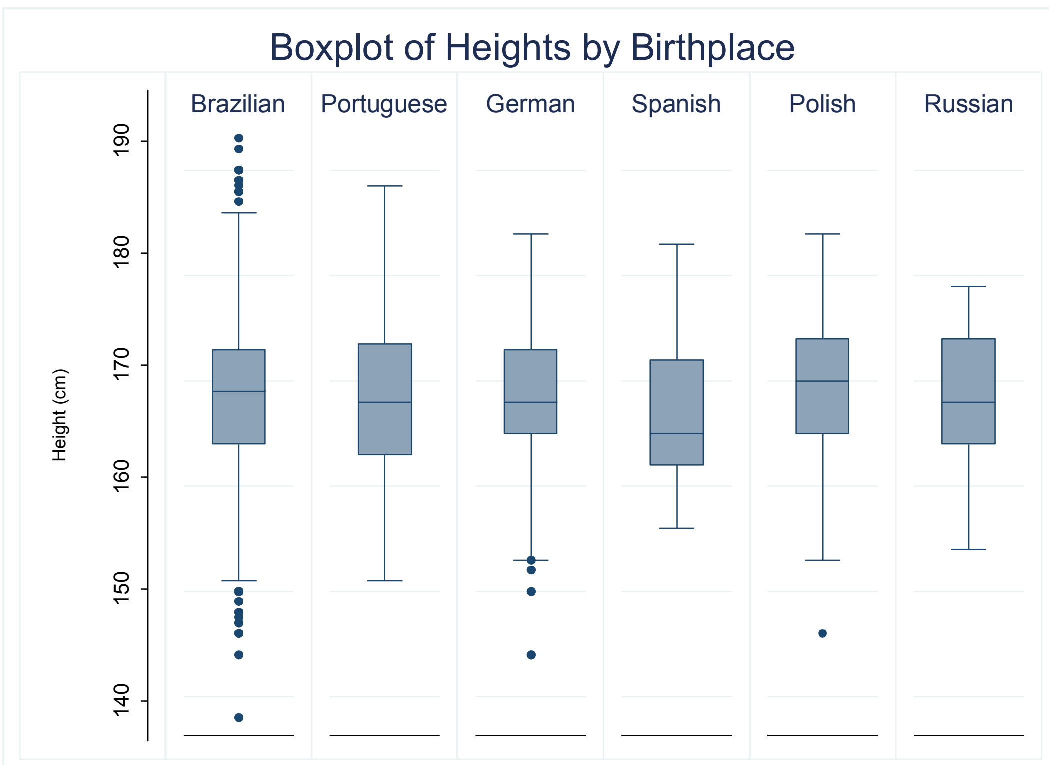
172 The caveat, however, is that obtaining naturalized Brazilian citizenship was not difficult at this time. Therefore, I can only speculate that the majority of the foreign-born passport bearers were not repatriation but rather traveling for leisure or business with plans to return to Brazil.

173 The higher median value for the Polish males may be attributed to the smaller sample size of individuals in that category (n=29).

we examine the mean values for individuals across these categories, however, the value for Brazilian-born males is slightly higher (at 168.68 cm). Based on this cross-sectional comparison, we can sustain that immigration to Brazil during the late-nineteenth and early-twentieth 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. Robustness checks in that chapter endeavored to isolate soldiers with non-Iberian surnames, but with the passport records, we can see that even Portuguese and Spanish immigrants did not hold a height advantage over Brazilians.

Figure 5.8



5.6. Conclusion

This chapter analyzes the ancillary dataset of passport bearers. As we have seen, this dataset is much more selected than that of the military, with the sample of passport bearers favoring the upper socio-economic groups, i.e., a majority of elite, skilled, and semi-skilled individuals. Trends in the height of passport bearers also denote some improvement in health in the late-nineteenth century, although the upward trend is much less pronounced than that found amongst Brazilian soldiers. Nevertheless, amongst those passport bearers listed as unskilled, average heights did exhibit an increase in magnitude similar to that found in the AHEX dataset, increasing from 162.6 cm for those born in 1880 to 166.3 cm for those born in 1910.

In addition to analyzing native-born Brazilian passport bearers, this chapter also examines a sub-sample of foreign-born passport bearers. Graphical tools compared the ranges of heights amongst Brazilian, Portuguese, German, Spanish, Polish, and Russian passport bearers in order to illustrate that the heights of immigrants were not superior to those of the native-born.

In the next chapter, we will compare these height estimates with those of the military dataset and other historical heights studies on Brazil.

Appendix

Table 5.2

VARIABLES	1	2	3	4	5
Dep. Var.: Height	**Males**	**Females**	**Males DF**	**Males N&NE**	**Males S&SE**
cohort1870	ref.	ref.	ref.	ref.	ref.
cohort1875	-0.506	-1.468	-0.558	-1.801	-0.446
cohort1880	1.001	-0.55	2.156*	-1.766	1.470*
cohort1885	0.495	0.742	1.431	-2.869	1.103
cohort1890	0.303	-0.242	1	-2.529	0.815
cohort1895	0.712	-1.363	1.447	-3.023*	1.349*
cohort1900	0.752	-0.671	1.225	-1.587	1.096
cohort1905	1.928*	1.688	3.188*	-1.665	2.407**
cohort1910	1.461	5.826	3.113	-6.394	1.667
unskilled	-6.160***	-6.912***	-5.661***	-6.226***	-6.054***
non_white	-1.632**	-2.076	-0.566	-1.751	-1.611**
north	0.564	-1.963		0.821	
south	-0.328	-0.0477			-0.304
southeast	ref.	ref.			
centerwest	-1.725	1.796			
northeast	-0.245	-1.413			
age16	-1.393	-4.569	-3.337*	-0.263	-1.262
age17	-0.618	-2.083	0.535	-4.163	-0.04
age18	0.134	-1.838	-0.109	1.791	-0.207
age19	-1.628*	-1.186	-2.27	-3.308	-1.359
age20	1.647*	-1.548	1.986	0.664	1.881**
age21	-0.281	0.507	0.475	-0.00697	-0.249
age22	0.171	0.983	0.704	1.421	0.346
Constant	169.0***	169.6***	168.1***	171.7***	168.4***
Observations	3,897	694	1,466	634	3,151
R-squared	0.092	0.156	0.091	0.117	0.091

Notes

*** p<0.01, ** p<0.05, * p<0.1

In Specifications 1 and 2, omitted categories are the birth cohort of 1870, southeast, skilled/elite, and over the age of 23. Except for the region variable, the same reference categories apply to Specifications 3 through 5.

Table 5.3

Comparisons of Brazilian versus Foreign-Born Passport Carriers

Country	N	Mean	S.D.	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

Chapter 6. Discussion and Comparison of Brazil's Height Trends

Introduction

Until this point, this dissertation has focused on the importance of studying the evolution of heights in Brazil in the nineteenth and twentieth centuries; the characteristics of the military and passports samples used herein; and the trend estimates derived from multiple regression analyses of both samples. As seen in Chapters 4, regression results from the military dataset indicate that the average height of the typical Brazilian remained low and stagnant in the nineteenth century, while a marked increase in stature began in the late-nineteenth century and tapered out in the 1920s. The trend estimates point to another period of stagnation in the 1920s and 1930s, before a return to modest growth in height in the 1940s and 1950s. In addition, results from the military dataset illustrate a long-term gap in the average height of soldiers born in northern and southern regions, although this regional inequity attenuated mildly in the early-twentieth century. Chapter 5 presented results from the ancillary dataset of passport bearers, which fail to depict such a regional discrepancy in heights. Trend estimates based on the sample of passports indicate that the heights of upper-class Brazilians increased to a lesser degree than the heights of unskilled individuals. This chapter endeavors to contextualize Brazil's height trends, and, to the extent possible with the evidence available to the researcher, uncover explanations behind both the temporal and regional patterns.

The discussion proceeds in three sections. First, in Section 6.1, I compare the results from the military and passports samples with other historical height estimates of

Brazil and with those of other nations during the period in question. Secondly, Section 6.2 discusses the temporal trends in height, at both the national and regional levels. To that end, this section situates the time trends within the relevant historiography and incorporates additional data on population health and public-health spending. Thirdly, Section 6.3 presents evidence on dietary patterns and the epidemiological environment to proffer explanations for the longstanding regional height discrepancy observed between northern and southern regions of the country. I argue that income growth and the earlier initiation of public-health reforms explain the upward height trends in Brazil's southern regions, while the latter was most crucial for the northern territories in which income growth was less accentuated and the epidemiological environment was more severe. Furthermore, I suggest that Brazil's long-term health inequities between regions reflect geographic endowments underpinning both the epidemiological environment and regional discrepancies in dietary patterns, rather than socio-political factors.

6.1. Comparing Brazil's Historical Height Estimates

As discussed in Chapter 2, there are four existing historical height studies based on archival records that cover Brazil in the period studied here. In addition, there are also several studies based on official nutritional surveys that cover the late-twentieth century. While I previously referred to some of the strengths and weaknesses associated with these sources, my discussion here will enter into a more critical assessment of their height estimates vis-à-vis those of the military dataset. To that end, Figure 6.1 depicts the height estimates drawn from prison records, worker registration cards, the Brazilian navy, and official government surveys. Intriguingly, trends for that period based on army soldiers are consonant with findings from naval recruit records, both in terms of trends and levels.[174] However, specifically for the pre-1940 period, the Brazilian military appears to be the least biased source for historical anthropometric research.

When comparing the results from the study based on records of the Rio de Janeiro city jail, I consider the regression model in which immigrants are omitted to be the preferred specification.[175] The estimates derived from the sample of prisoners indicate that heights stagnated in the early- and mid-nineteenth century, while there is a slight, positive upward trend from 1860 to 1880.[176] Prior to the 1870 birth cohort, prisoners were roughly 1.5 to 2 centimeters shorter than soldiers. This discrepancy is likely explained by the occupational bias associated with prison records in the estimation of historical height trends. Since individuals of the lower socio-economic statuses were the most likely to succumb to criminal activities, we can reasonably assume that the prison sample captures a disproportionate amount of shorter individuals. However, even though the sample drawn from Rio de Janeiro's city jail potentially over-represents the lower socio-economic statuses of Brazilian society, anthropometric historians have found that there can be a positive bias associated with prison height samples.

In comparing potential biases emanating across varying institutional contexts for sources of heights, Baten and Blum indicate a positive (although not statistically

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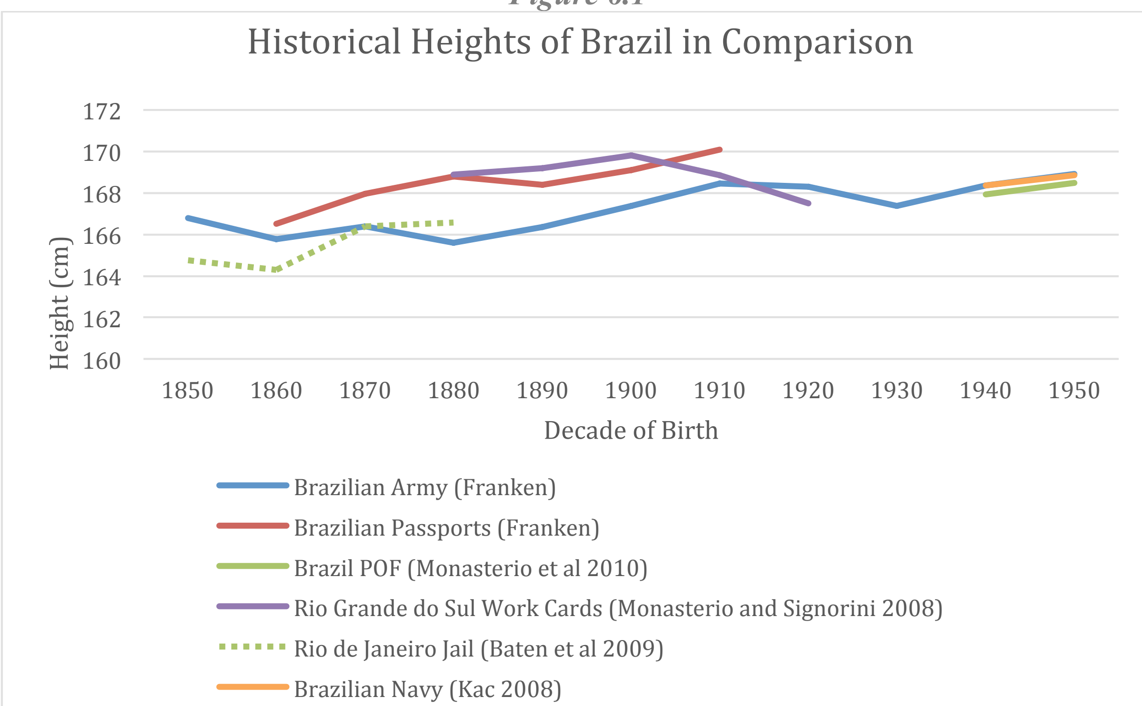
174 "Tendência Secular Em Estatura Em Recrutas Da Marinha Do Brasil Nascidos Entre 1940 E 1965.," *Cadernos de Saúde Pública* 14 (1998): 109–17.

175 Baten et al. argue that including or excluding immigrants from the prison sample changes the overall pattern of the results minimally. However, with immigrants excluded, the constant is 1 cm smaller. For purposes of comparison, I use Baten and co-authors' regression model that excludes immigrants as the preferred specification since few immigrants entered into the military.

176 Baten, Pelger, and Twrdek, "The Anthropometric History of Argentina, Brazil and Peru during the 19th and Early 20th Century."

significant) bias from prison data.[177] It would appear that the logic behind this discrepancy has to do with criminal selectivity; individuals had to be taller and stronger to commit crimes, especially in the case of violent crimes. Issues of selection aside, the fact that both the prisoner and military data point to the same general trends is reassuring. In both samples, there is a slight diminution in stature from the 1850 to 1860 birth cohorts, and an upward trend between 1860 and 1870. However, Brazilian prisoners born in the 1870 birth cohort attained levels of stature comparable to the soldiers in my sample, while those born in the 1880 cohort of birth were approximately 1 cm taller than estimates derived from the military. The explanation behind this discrepancy remains unclear. A brief comparison of the regional height estimates based on the military and prisoner data may throw additional light on potential shortcoming of the prisoner records.

Figure 6.1



[177] Joerg Baten and Matthias Blum, "Growing Tall but Unequal: New Findings and New Background Evidence on Anthropometric Welfare in 156 Countries, 1810-1989.," *Economic History of Developing Regions* 27, no. sup1 (2012): S66–85.

When disaggregated by region, the prisoner data collected by Baten et al reveal a pattern by which heights from the North and Northeast of Brazil were comparable to those found in the South and Southeast until roughly 1860, but those from the North/Northeast advanced at a quicker rate thereafter. By 1870, prisoners from the Northeast were over 1 centimeter taller than those from the South or Southeast. Despite the intriguing upward trend, prison records are likely to overstate the height of individuals hailing from these northern regions. The higher heights of Northeastern prisoners likely reflected their migrant status; individuals born in the 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. For this reason, I contend that the military sample is more appropriate for capturing trends in stature at the national and regional levels.

Worker registration cards from the state of Rio Grande do Sul exhibit relative stagnation in height, with annual averages vacillating between 168.9 and 170.2 centimeters 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. As seen in Chapter 2, climatic conditions in Southern Brazil implied less risk of contracting tropical diseases such as malaria. The higher overall heights of those born in Rio Grande do Sul is consistent with evidence from the military dataset; however, the lack of any significant time trends, save the decline in stature associated with the WWI period, is cause for concern. As Monasterio and Signorini state, worker registration cards are unlikely to capture a broad cross section of the population. Since both the poor, primarily engaged in informal labor, and the rich were unlikely to use worker registration cards, it is possible that they do not convey a representative image of the Rio Grande do Sul population. Notably absent from their study are any men engaged in agricultural labor, at a time when primary-sector employment in the Southern region of Brazil was on the order of 70.1 percent.[178]

The military cohort estimates from 1940 and 1950 coincide almost perfectly with estimates based on data from government surveys analyzed in Monasterio et al.[179] The IBGE proclaims that the 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. One potential reason for this slight discrepancy is the method of adjusting the heights of individuals older than 50 at the time of the survey. Anthropometricians tend to disagree about the best method to adjust the heights of individuals after the age of 50.

Brazilian Heights in International Comparison

Having assessed other historical height estimates of Brazil and determined that the military sample provides the most accurate vision of population height trends, it is worthwhile here to discuss the evolution of heights in Brazil in comparison with other nations. As discussed in Chapter 2, Steckel argues that it is important to consider the starting date of industrialization in a country with respect to the genesis of the germ

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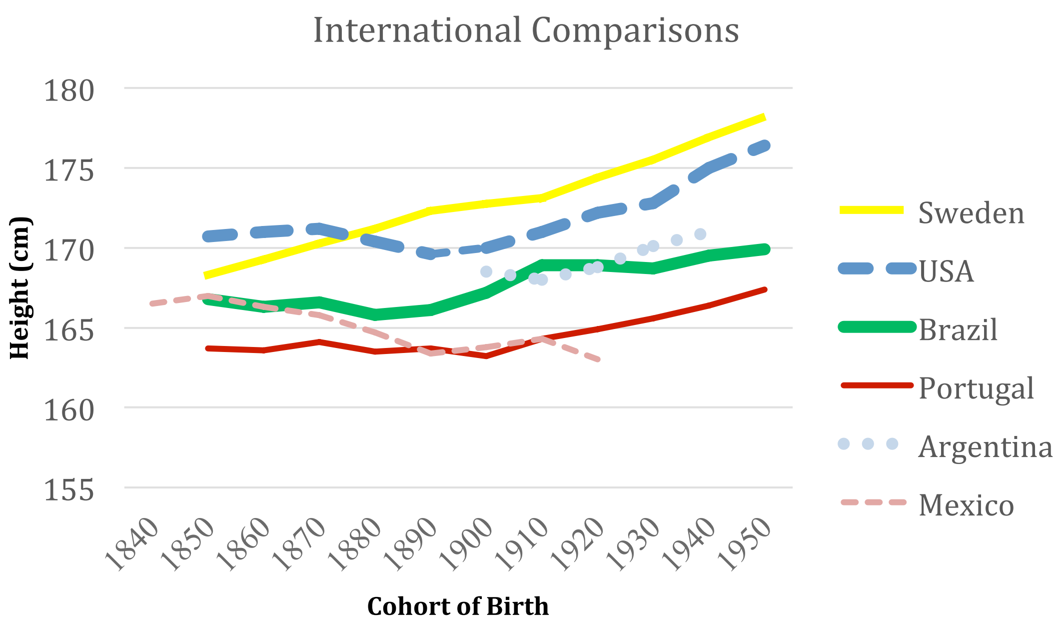
[178] Annibal Villanova Villela and Wilson Suzigan, *Política Do Governo E Crescimento Da Economia Brasileira, 1889-1945.* (Rio de Janeiro: IPEA/INPES, 1973).

[179] Monasterio, Noguerol, and Shikida, "Growth and Inequalities of Height in Brazil, 1939-1981."

theory of disease. The next graph below compares the trends in height in Brazil with the United States and also with several late-industrializing nations.

Figure 6.2



The US trends display what is referred to as "the antebellum puzzle." Heights began trending downwards in the US in the 1860s and only began to increase again in the 1880 birth cohort. This downward trend was so puzzling to researchers for some time because it occurred during a period in which macroeconomic indicators point to an improvement in overall standards of living. However, as noted, the US began its path to industrialization prior to the emergence of the germ theory of disease in the late-nineteenth century. Overcrowding in urban areas and the integration of markets, which accelerated the proliferation of diseases, were the main culprits of this decrease in stature in the mid-nineteenth century US.[180]

[180] Costa, Dora and Richard Steckel, "Long-Term Trends in US Health, Welfare, and Economic Growth.," in *Health and Welfare during Industrialization* (Chicago: University of Chicago Press, 1997), 47–89.

When we compare the national height trends of Brazil with other late-industrializing nations, we can see that the height increase in the 1880-1910 period was large by international standards. The solid green line pertains to Brazil, and we can see that heights in Brazil were comparable to those in Mexico for much of the 19th C. Brazilians were consistently taller than the Portuguese. Compared with these other nations, there are no cases in which heights increased so rapidly over a three-decade period. The rate of gain during the 1880 to 1910 interval in both Sweden and the US was inferior to that of Brazil.[181]

6.2. Time Trend Analysis and Discussion

Nineteenth-century stagnation

In 1850, baseline regressions results (Chapter 4) reveal that average stature in Brazil hovered around 166 cm from 1860 to 1880. By 1880, this figure had reached 165.6, denoting a slight decline in health and living standards. As discussed in Chapter 1, the stagnation in heights in the mid-nineteenth century can be explained by the system of governance characteristic of Imperial Brazil based on slavery and clientelism. Further, there was a lack of coherent government policies concerning the poor and little regulation in public-health matters.

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181 Sources: Sweden: L Sandberg and R. Steckel, "Was Industrialization Hazardous to Your Health? Not in Sweden!" in *Health and Welfare during Industrialization*, ed. R. Steckel and R. Floud (Chicago: Univerisity of Chicago Press, 1997). USA: see prev. note. Brazil: AHEX dataset, fitted values from baseline regressions. Portugal: Yvonne Stolz, Joerg Baten, and Jaime Reis, "Portuguese Living Standards, 1720-1980, in European Comparison: Heights, Income, and Human Capital.," *Economic History Review* 66, no. 2 (2013): 545–78. Argentina: Ricardo D. Salvatore, "Better Off in the Thirties: Welfare Indices for Argentina, 1900-1940.," in *Living Standards in Latin American History: Height, Welfare, and Development, 1750-2000*, ed. Ricardo D. Salvatore, John H. Coatsworth, and Amílcar Challú (Cambridge, MA: Harvard University Press, 2010), 127–65. Mexico: López-Alonso, *Measuring Up: A History of Living Standards in Mexico, 1850-1950*.

To say that there were no interventions in sanitation and hygiene in the nineteenth century, however, would be somewhat erroneous. Beginning in the mid-nineteenth century, consistent epidemics gave a general impetus to improve sanitation services in the nation's capital city of Rio de Janeiro. The ecological program of the Empire rejected the germ theory of disease and instead focused on miasmas, or local conditions supposed to propagate disease such as marshy water, sewage, and poorly-ventilated urban spaces. Although it did not adequately identify causative factors, it associated disease with living conditions in urban life, and it generated the first urban services (water, sewage, and trash collection).[182] The limited success of these early measures can be attributed to the lack of coherence between interventions over time, and the comparative lack of financial resources characteristic of public services in Imperial Brazil.

The Early First Republic, 1890-1914

From 1880 to 1910, average stature in Brazil increased from 165.6 to 168.8 cm, denoting an average decadal gain of approximately 1.1 cm. Determining whether improvements in sanitation and healthcare or in real income explained the brunt of the increase in stature is difficult given current data limitations. On the one hand, there were favorable macro-economic conditions that stimulated growth. The increase in stature coincided with the phase of industrial growth primarily fueled by exports as well as the transition to a wage-based economy. On the other hand, concomitantly, there was an improvement in the provision of hygiene and sanitary services. The late-nineteenth century saw a host of innovations in sanitation and hygiene as Brazilians sought to join the ranks of the world's 'modern' nations. This period also saw the expansion of Western medicine based on the germ theory of disease.

[182] Hochman, *A era do saneamento.*

The federal government pursued public health initiatives with greater vigor in the First Republic. Meade views the 1889 bill on public health and sanitation as a point of disjuncture with Imperial policies regarding health: "Although the 1889 law was only partially implemented, it marked a change in the previously chaotic methods of combating disease in Brazil."[183] The new bill created centralized plans to modify prophylactic measures, sanitation codes, and medical care. The 1891 Constitution established sanitation and health as the purview of the municipalities and states.[184] As the individual states gained the ability to impose export duties, thus bolstering their tax bases, there was an increase in funding for basic government services such as education and hard infrastructure.[185]

The 1900s ushered in an era of increased state activism in health matters. Hochman delineates the 1900s as the decade of urban reforms and the 1910s as the decade of rural hygiene.[186] In 1902, the government sanctioned a law imposing a system of compulsory notification to identify persons with yellow fever, cholera, bubonic plague, smallpox, diphtheria, typhoid fever, tuberculosis and leprosy. As discussed in Chapter 1, a 1904 law required mandatory smallpox vaccination—a law that provoked the infamous Vaccine Revolt in November of that year. In 1907, a federal mandate created the *justiça sanitaria* (the sanitary justice or court), a regulatory body that presided over civil and

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183 Teresa A. Meade, *Civilizing Rio: Reform and Resistance in a Brazilian City, 1889-1930.* (University Park, PA: The Pennsylvania State University Press, 1997), 79.

184 In actuality, the Constitution of 1891 made no explicit mention of health work. However, Articles 5 & 6 indicate that such matters would fall upon the individual state and municipal authorities. See Hochman, *A Era Do Saneamento*, 95-6.

185 See Musacchio, Fritscher, and Viarengo, "Colonial Institutions, Trade Shocks, and the Diffusion of Elementary Education in Brazil, 1889-1930."

186 Hochman, *A Era Do Saneamento*, 55.

criminal cases related to infractions against sanitary regulations. In the capital city of Rio de Janeiro, these new measures revealed the First Republican state's enhanced regulatory capacity in issues of public health and hygiene.[187] In the 1910s, officials turned to combat rural epidemics such as hookworm and Chagas disease, and Brazilian intellectuals became aware of the dismal living conditions prevailing in the country's interior. In Chapter 4, we saw that the heights of soldiers born in the Northeast increased rapidly between the birth cohorts of 1900 and 1910 (with an increase of roughly 3.5 cm), and this upsurge in stature substantiates the timing of these rural public-health interventions. In Chapter 7, we shall hone in on hookworm eradication schemes as a fundamental aspect of the rural hygiene movement.

In interpreting the motivation of these new public-health initiatives, many historians have subscribed to a Foucaultian view on increased surveillance mechanisms.[188] Given the upward trend in stature associated with the first decades of the First Republic, I argue that the increase in state monitoring capacity ultimately had a positive impact on health in Brazil. The transition to republicanism allowed for officials to more closely survey the population for malicious behavior. For example, by strengthening policing and inspecting institutions, the state was able to tackle issues that arose from the provision of fraudulent milk. In addition, strengthened surveillance and health institutions allowed for fuller identification and quarantine of infected persons.[189] The Republican state also made great strides in inspecting municipalities for potentially

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[187] Ibid., 99.

[188] See Needell, *A Tropical Belle Epoque: Elite Culture and Society in Turn-of-the-Century Rio de Janeiro*.

[189] Jaime Larry Benchimol, *Dos Micróbios Aos Mosquitos: Febre Amarela E a Revolução Pasteuriana No Brasil.* (Rio de Janeiro: Editora Fiocruz / Editora UFRJ, 1999), 250.

dangerous behavior from commercial establishments (such as the improper disposal of animal blood from butchers near or in public waterways). In addition, municipal authorities also promoted awareness about the habitat of malarial mosquitos. Further, increased surveillance allowed for regulating bodies to more fully eradicate methods of 'folk' healing. The reformers that sought to modernize Brazil through medicine did so by displacing traditional healing methods that were not in line with Western science.[190]

Other early interventions aimed at improving health conditions were less heavy handed. Otovo has highlighted the efforts of the *maternalista* movement to provide welfare services in the late-nineteenth and early-twentieth centuries.[191] As the quotations from Barão do Lavradio included in the introduction to Chapter 4 summarized, the medical elite was concerned with mercenary and artificial nursing in the nineteenth century. Students at the medical schools of Bahia and Rio de Janeiro composed a number of studies alerting to the ill-health effects of *aleitamento artificial* (or artificial nursing, usually by way of cow, goat, or donkey milk) beginning in the 1870s. The rudimentary instruments used to administer feedings to children—normally a fine sponge and cloth tied on the opening of a cup or bottle—allowed for the proliferation of bacteria.[192] This intellectual push for maternal breastfeeding or for cleaner artificial nursing saw concrete actions from the state in the late-nineteenth century, although these efforts were predominantly concentrated in the Southeast.

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190 Luiz Antonio Castro-Santos, "Power, Ideology, and Public Health in Brazil, 1889-1930." (PhD Dissertation, Harvard University, 1987), 127.

191 Okezi Otovo, "To Form a 'Strong and Populous Nation': Race, Motherhood, and the State in Republican Brazil" (PhD Dissertation, Georgetown University, 2009), Introduction.

192 Maria Luiza Marcílio, *História Social Da Criança Abandonada* (São Paulo: Editora Hucitec, 1998), 250.

The first campaigns to improve artificial nursing for working-class mothers in Brazil emerged in the 1890s. The French system of the *gottes de lait* (literally, drops of milk), which had seen great success in Europe, was implemented in Brazil under the Portuguese translation, *gottas de leite*. These centers distributed sterilized milk to children that had been registered at their facilities. According to Marcílio, in Rio de Janeiro, the first *gottas de leite* were headed by the Instituto de Proteção e Assistência à Infância, or the IPAI (Institute for the Protection of and Assistance to Infancy), created in 1899 by Moncorvo Filho to distribute free milk to mothers in need. Every morning, the *gottas* distributed baskets of personalized and sterilized baby bottles. In addition, every week they weighed the registered children. The *gottas* also provided smallpox vaccines, and gave advice to the parents.[193]

Otovo's periodization of the advent of the *gottas* is slightly earlier, dating the emergence of well-baby clinics, wet-nurse inspections, and the *gottas de leite* in the 1880s in Rio de Janeiro.[194] This could explain why stature in the Southeast began to rise in the 1880 birth cohort, while the upsurge in stature was delayed elsewhere. In addition to the immediate benefit of providing pasteurized milk, the *gottas de leite* also functioned as centers for the dissemination of medical knowledge. Marcílio notes that the *gottas* brought many poor women into contact with doctors that instructed them in proper hygiene and the sterilization of milk.[195] Other social welfare institutions that emerged in this period were the c*reches,* or daycare centers, which provided childcare for lower-class

[193] Ibid., 252.

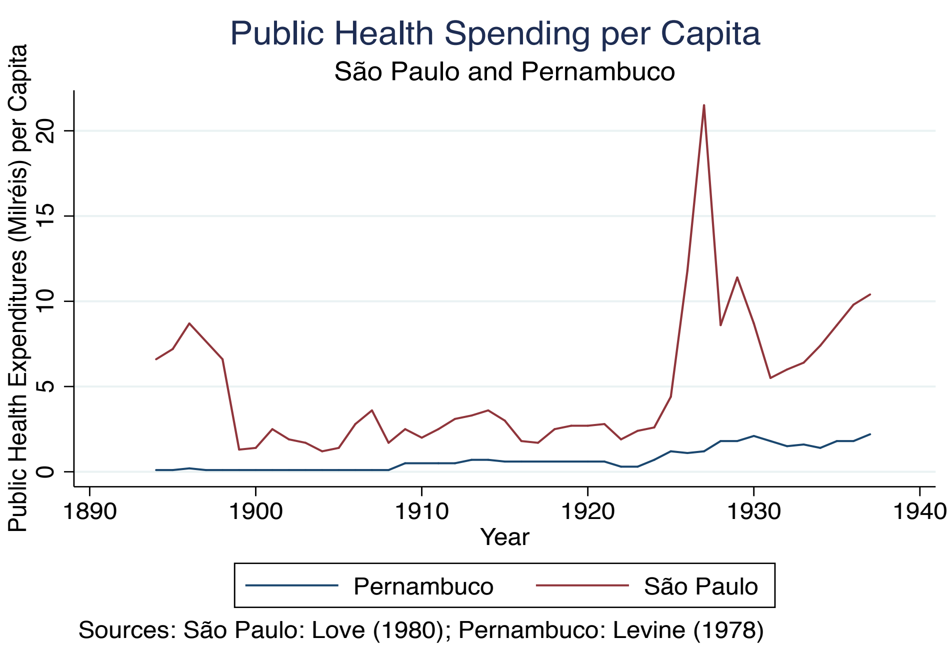
[194] Otovo, "To Form a Strong Populous Nation." 30-31

[195] Marcílio, *História Social Da Criança Abandonada*, 252.

mothers. These daycare facilities were crucial for women to return to the workforce, providing extra income for working-class families without sacrificing on childcare.[196]

Given the divergent height trends across regions, it is necessary to consider the extent to which advances in medicine and sanitation were diffused evenly throughout Brazilian regions. To that effect, Figure 6.3 displays available published statistics on per capita public health expenditures in two different states, São Paulo and Pernambuco. Although such data are available for only a handful of states, it is reasonable to view these cases as archetypical of spending patterns in their respective regions. One can note that public health expenditures per capita were much lower in the state of Pernambuco throughout the period from 1890 to 1940. There was a rapid expansion of per capita spending in the state of São Paulo, and the rate remained substantially higher than that seen in its northeastern counterpart.

Figure 6.3



[196] Ibid., 251.

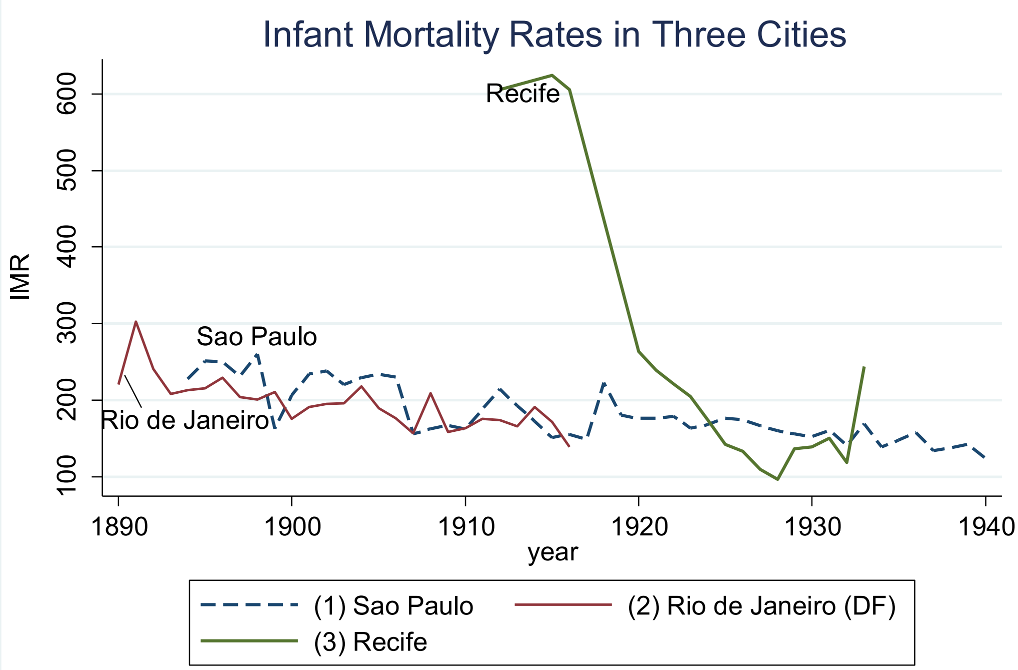
In addition to health spending, this subsection also traces trends in the epidemiological environment in an effort to corroborate the observed trends in stature. Specifically, I incorporate statistics on infant and disease-specific mortality rates. We will recall from Chapter 2 that particular diseases such as enteritis and malaria are well known causes of stunting of heights. The evolution of stature analyzed with the aid of disease-specific mortality rates reveals that there was an improvement in the disease environment during the initial decades of the First Republic, and I argue that the earlier upward height trend observed in the Southeast is reflective of this improvement.

Statistics on infant mortality and disease-specific mortality rates offer a window into the effectiveness of these measures enacted in the initial decades of the First Republic. As we can see in Figure 6.4 below, there was a precipitous decline in the infant mortality rate in Rio de Janeiro beginning in the 1890s, dropping from its highest rate of 300/1000 to less than 150/1000 by 1915. The information available for the city of São Paulo also indicates that infant mortality began to decline in the late-1890s, dropping from a high of roughly 250 to 151/1000 by 1915. Data on the city of Recife, Pernambuco are spottier than those for Rio de Janeiro and São Paulo, yet they denote a very high level of infant mortality in 1912 and 1915-16 and a precipitous decline in the rate by 1920.[197] The earlier diminution in the rate of infant mortality in both São Paulo and Rio de Janeiro seems to reflect the earlier implementation of sanitary and infant-health reforms in the Southeast. The decline in IMR for these cities is relatively contemporaneous with the earlier upward trend in height in the Southeast. It is puzzling that the rate of infant mortality fell so abruptly in Recife from 1916 to 1920 since, as discussed above, public

[197] The *Annúario estatístico de Pernambuco* (1933) offers data on the deaths of infants from 0-1 years of age from 1900 to 1933; however, the only years in which the total number of live births are reported are 1912, 1915, 1916, and 1920-33.

health expenditures per capita in the state of Pernambuco did not increase substantially until the mid-1920s. Additional evidence for the 1920s through the 1940s indicates that such a drastic improvement in Recife was short lived, as infant mortality rates oscillated between roughly 250 and 350 per 1000.[198] The much higher rate of infant mortality in Recife indicates that the epidemiological environment in the Northeast was far more severe than that of the Southeast—one potential explanation for the long-term height gap between the northern and southern regions of Brazil.

Figure 6.4



Sources: (1) Fun. SEADE; (2) AEDS-Rio (1926); (3) Ann. estat. de Pernambuco (1933)

In both Rio de Janeiro and São Paulo, there is considerable evidence to suggest that the interventions municipal authorities made in the late-nineteenth century had a greater impact on public health than previously supposed. Hochman and Benchimol view

[198] US Department of Commerce, *Brazil, Summary of Biostatistics: Maps and Charts, Population, Natality, and Mortality Statistics* (Washington DC: Bureau of the Census, 1948), 109-114.

the 1900s as the watershed moment in public health,[199] yet infant and infectious-disease mortality rates suggests that conditions began to improve as early as the 1890s. In São Paulo city, transmissible diseases resulted in the death of 6.93 out of every 1,000 persons in 1894. This figure fell to 2.13 by 1916, denoting a 69 percent decline in transmissible disease mortality.[200]

Death rates from dysentery, typhoid, and malaria also aid in understanding the upward trend in heights in the 1880-1910 period. The record on the decline in mortality from malaria is perhaps more striking than the figures on deaths from all infectious diseases. In both cities, public-health initiatives focused on malaria, yellow fever, and the plague began in the 1890s. Prior to the 1890s in Rio de Janeiro, yellow fever resulted in the death of nearly 5 out of every 1,000 residents. By 1904, yellow fever mortality fell to virtually zero.[201] Figures 6.5 illustrates the improvement in the disease environment Rio de Janeiro. Figure 6.6 additionally depicts the decline in malaria mortality in Rio de Janeiro and São Paulo.[202]

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[199] Hochman, *A era do saneamento*; Benchimol, *Dos micróbios aos mosquitos*.

[200] John Allen Blount III, "The Public Health Movement in São Paulo, Brazil: A History of the Sanitary Service, 1892-1918." (PhD Dissertation, Tulane University, 1971), 202.

[201] Directoria Geral de Saude Pública Brasil, *Annuário de Estatística Demographo-Sanitária, 1915-1916.* (Imprensa Nacional, 1926). Hereinafter, AEDS.

[202] For Rio de Janeiro, AEDS, 1926. Data for São Paulo from Blount, "The Public Health Movement," 204.

Figure 6.5

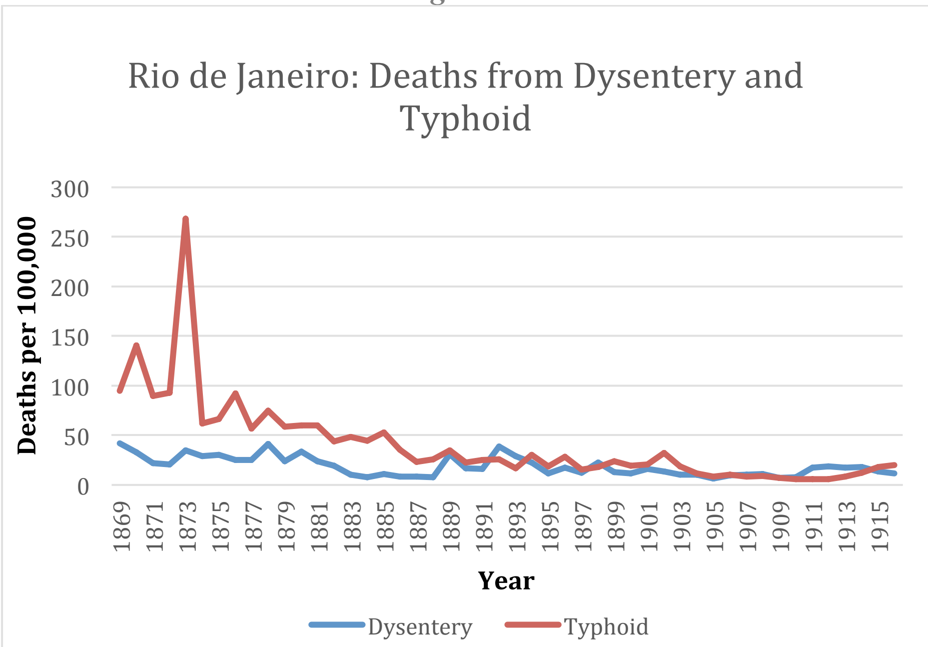
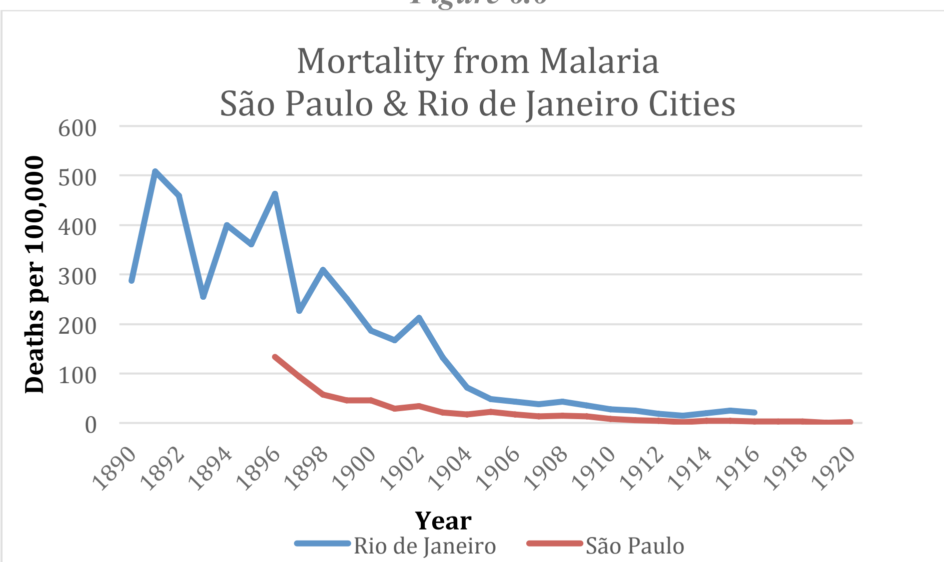


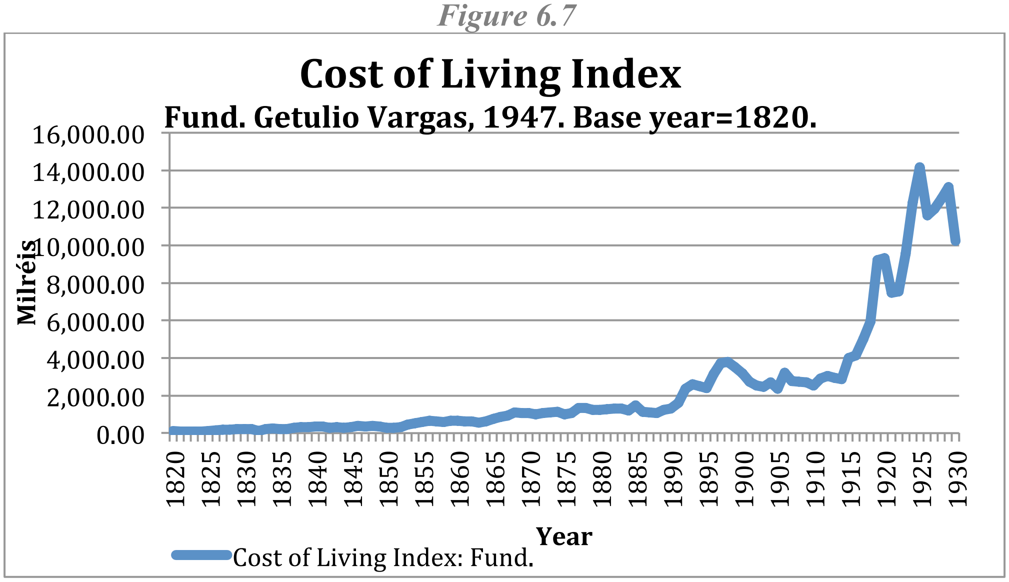
Figure 6.6



WWI and The Vargas Period

After an unprecedented increase in stature over the three decades from 1880 to 1910, heights stagnated in Brazil in the 1920s before falling slightly during the 1930s. Recalling that heights are determined jointly by health and nutritional status helps us explain the stalling of growth in the WWI era. Due to the changes in the world market associated with the war, the price of Brazilian products rose, and domestic inflation rates began to climb with them. Using 1820 as the base year, Figure 6.7 plots the cost of a basket of foodstuffs for the 1820-1930 period—a cost of living index computed by the Fundação Getúlio Vargas in 1947.[203] We can observe a clear increase in inflation beginning roughly in 1914. I argue that political instability and inflationary pressures extending into the 1920s are to blame for leveling-out of height growth seen in the 1920 birth cohort. One labor newspaper stressed that, while wages grew by 150 percent between 1914 and 1927, the cost of living had increased 280 percent from 1920 to 1927.[204]

Figure 6.7



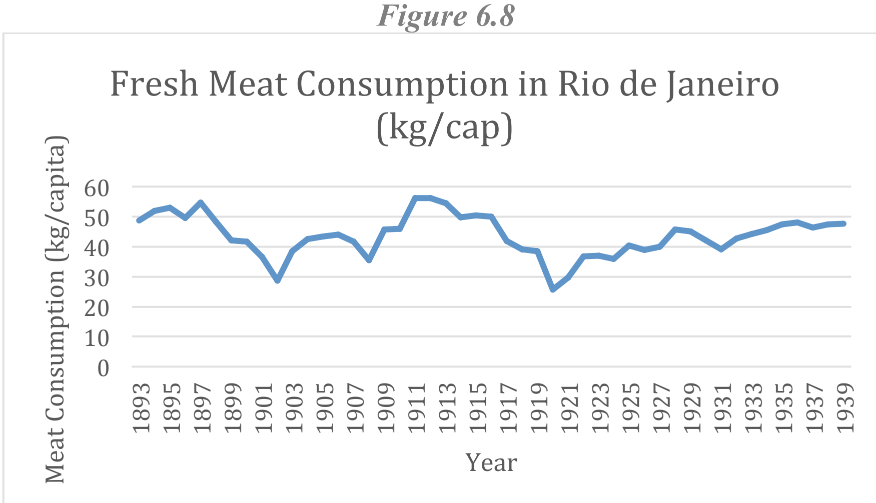
The erosion of wage-earners purchasing power likely implied a reversal of the positive trends observed in the 1890 through 1910 birth cohorts. Reduced real income likely meant that more families lived in squalid conditions, frequently with shared toilet

203 Data accessed at http://www.ipeadata.gov.br

204 M. A. Guzzo de Decca, *Industria, Trabalho E Cotidiano: Brasil, 1880 a 1930.* (São Paulo: Atual Editora, 1991)., 44-5.

facilities. Hygiene-improving products like soap were purchased with greater difficulty. Further, facing higher food prices, consumers likely responded by reducing their intake of high-quality animal proteins or by decreasing caloric intake altogether. This can been seen in Figure 6.8, which displays per capita meat consumption over the 1893-1939 interval for Rio de Janeiro city.[205] Although this meat consumption index only corresponds to one location, it is likely that urban dwellers throughout Brazil experienced similar changes in dietary patterns. However, given the availability of food at or near farm-gate prices in the countryside, rural inhabitants likely experienced the erosion in consumptive capacity to a lesser degree. In the 1920s, the negative influence on stature associated with higher prices counteracted the positive influence caused by improved public-health measures, and this effect was likely more pervasive in urban areas.

Figure 6.8



The Great Depression ushered in a period of lower coffee prices on the world market. The waning performance of the coffee sector was likely the cause of the reduction in overall stature seen in the 1930s. Falling coffee prices in general implied

[205] IBGE Brasil, *Anuário Estatístico Do Brasil V 1939-40* (Rio de Janeiro: Instituto Brasileiro de Geografia e Estatística, 1940).

lower wages (especially for those employed in agriculture), higher domestic prices, and depressed local demand. For urbanites, the consistently rising level of prices in general and their persistent volatility meant that the average Brazilian had more difficultly investing in health-augmenting products. This was particularly true for the urban poor that was so frequently relegated to *favelas*, or urban slums. Written testimony from favela-dwellers in the 1950s describes the difficulties many faced to buy simple necessities like footwear and soap.[206]

Mean stature began to incline again in the 1940s, but it did not reach the velocity of change observed in the period ranging from 1880 to 1910. The modest growth in stature in the post-1940 period is befuddling given estimates on economic growth and the presumed achievements in human welfare during the Vargas era. Researchers sustain that GDP grew at an average rate of over 6 percent from 1930 to 1980.[207] The Brazilian economy may have grown substantially during that interval, but the question remains whether added wealth was distributed to the vast cross-section of the population. The leader heralded as *pai dos pobres* (father of the poor) may more adequately be described as *pai dos empregados* (father of the employed), since the relative decline in the growth of average height may reflect increased levels of union-induced unemployment. Moreover, setting a minimum wage did little to assure that salary growth outstripped the inflationary spiral that had begun in the WWI era. While wages grew by 20 percent from 1935 to 1945, the price of foodstuffs had risen 101.7 percent.[208]

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[206] Carolina Maria De Jesus*. Child of the Dark.* (Rio de Janeiro: Dutton, 1962).

[207] M Abreu and D Verner, *Long-Term Brazilian Economic Growth, 1930-94* (Paris: Development Centre of the Organisation for Economic Co-operation and Development, 1997).

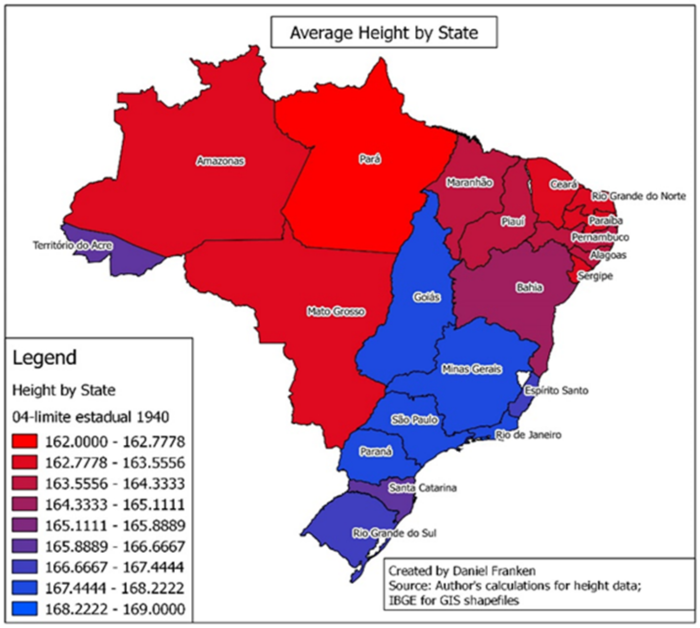
[208] Decca, *Indústria, trabalho e cotidiano*, 47.

6.3. Cross-Sectional Analyses and Discussion

Regional Height Patterns

Thus far our discussion has focused on changes in height over time. Although we have paid some attention to region-specific time trends, our analysis merits more in-depth discussion of spatial patterns in stature over the time period. Figure 6.9 demonstrates the average height of the entire sample by geographic area. We can readily observe a significant gap in stature. Although the map presents aggregated averages from the sample period and ignores time-period effects, it displays a clear divergence in average height between macro regions. On average, soldiers hailing from the North and Northeast were five to six centimeters shorter than those hailing from the South and Southeast. Although cross-sectional averages from this entire period could mask relative shifts in the regional disparities over time, we will recall from our discussion in Chapter 4 that these height differentials have remained relatively consistent throughout the study period. It is interesting to note that the gap was present in the cohorts prior to 1870, since various scholars have argued that the industrial expansion in the Southern regions of Brazil was responsible for the gap in living standards. Having established that this discrepancy in heights was so pervasive over the nineteenth and twentieth centuries, my discussion will now shift to proffering potential explanations for this persistent regional height gap.

Figure 6.9



Dietary Patterns

A myriad of factors can explain such persistent regional inequality in height: income differentials; discrepancies in the level and orientation of public spending; differences in access to healthcare and sanitation; regionally-varying practices of breastfeeding and weaning; and environmental and climatic factors. Since heights are partially determined by income, and income is in part dependent upon stature and cognitive ability, it is difficult to discuss income as a causal factor. We will recall from the Introduction that economic historians have disputed the emergence of regional income inequality in Brazil, with some analyses pointing to the concentration of industrial production in the Southeast, and others highlighting the divergence in export earnings from coffee and sugar, as the main cause. Since the evidence on heights suggests that regional inequities emerged before export earnings from coffee outstripped those from sugar, it seems unlikely that income alone is to blame. Table 6.4 in the Appendix to this chapter contains a set of regressions that analyze commodity prices for coffee and sugar as predictors of height, and the evidence suggests that commodity prices were not statistically significant in the time trends.

Traditional dietary patterns in Brazil provide one part of the explanation for the persistent north-south height gap. We will recall from Chapter 3 that both the quality and quantity of nutrients consumed over the growing years constitute a major input in the system that makes up terminal stature. In addition to gauging total caloric intake, one must take into account specific high-quality proteins and micro-nutrients that can have substantial effects on heights. Although nutritional surveys were not conducted until the late-twentieth century in Brazil, anecdotal descriptions of dietary patterns across regions can give us a general idea of the foods commonly consumed by working-class Brazilians. Below I present the basic components of the typical diet across regions and over time.

In general terms, the standard diet of the rural, working population consisted of beans, rice, manioc, and coffee. These staples were accompanied, at times, by pork, fish, and chicken. A multitude of tropical fruits, bananas, and oranges made their way into the diet of the common Brazilian since they have grown abundantly in the country. In the early-twentieth century, Wickliffe Rose, the General Director of the International Health Board of the Rockefeller Commission, noted that Vitamin A was one of the main deficits in the Brazilian diet. In a 1920 report, he stated, "In quantity, the diet is in the main apparently adequate. Its deficiency is in the element known as 'fat soluble A,' the chief source of which in human foods is milk, eggs, and green vegetables. The peasant regards milk as harmful, the eggs he sells, and green vegetables are not grown."[209] While the diet

[209] Wickliffe Rose, "Public Health Situation and Work of the International Health Board in Brazil" (International Health Board, October 25, 1920), RG 5 S3_305 B107 F1401, RAC, 22.

may have been sufficient in terms of quantity, it lacked key micronutrients. Some clinical studies have established a link between Vitamin A deficiency and stunting, although this may not be a direct effect of the micronutrient on skeletal development. The evidence suggests that, in addition to promoting healthy vision, Vitamin A is crucial in the regulation of the immune system.[210] Its absence in the diet of many Brazilians likely exerted a negative influence on stature by depressing immune-defense mechanisms, thus increasing the risk of disease.

Regional variations in dietary patterns likely underpinned the long-term regional height discrepancy. In *Geografia da fome* (or, The Geography of Hunger), the most authoritative reference on nutrition in Brazil, Josué de Castro asserts that the North Amazon territory traditionally 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. Notably absent from the diet in the North were sources of salt and iron. Travelers to the region commented on the practice of soil eating—a behavior that tends to emerge in populations with little iron.[211]

The sugar-producing and arid areas of the Northeast historically had a similar lack of quality animal protein. Records show that the typical diet in the Northeast consisted of higher amounts of dried beef (*carne seca*, jerked beef, or *carne do sol*, beef dried by solar radiation).[212] Salting and solar radiation have been proven to drastically lower the

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[210] Laura E. Caulfield et al., "Stunting, Wasting, and Micronutrient Deficiency Disorders," in *Disease Control Priorities in Developing Countries*, ed. Jamison DT Breman et al., 2nd ed. (Washington DC: World Bank, 2006), Ch. 28.

[211] Josué de Castro, *Geografia Da Fome* (Rio de Janeiro, 1952).

[212] K. F. Kipple, "The Nutritional Link with Slave Infant and Child Mortality in Brazil.," *The Hispanic American Historical Review* 69, no. 4 (November 1989): 677–90.

micronutrient content of beef.[213] In Pernambuco, observers noted bananas, manioc flour, beans, and rice as dietary staples.[214] The presence of African influence is notable in Brazil's Northeast. Palm oil, an ingredient figuring prominently in Northeastern cuisine, could have had the potential to increase Vitamin A levels due to its richness in B-carotene (a provitamin A, or a nutrient that the human body converts to Vitamin A after ingestion). However, the refining process for the edible oil generally removes all of the carotenoids.[215]

Contrastingly, the more temperate zones of the South and Southeast provided conditions more hospitable to agricultural production and cattle raising. In general, inhabitants of the South and Southeast consumed higher amounts of fresh vegetables and meats. In Minas Gerais, reports indicate that beef and pork were relatively cheap due to their abundance in the food supply: "The diet of the [*Mineiro*] people consists mainly of boiled beans, cooked with salt and pork fat, corn cakes, *mandioca* flour, rice boiled and cooked with fat and salt, beef and pork steamed or roasted, eggs and vegetables."[216]

Although the South is traditionally a cattle-producing region, within-region specificities did exist. In the state of Santa Catarina, observers from the Rockefeller Foundation noted:

> The staples of the diet along the coast are manioc meal, fish, and coffee. Many meals consist of nothing more. Fruits and vegetables place a very small part in the diet and fresh meat is a great rarity among the poor. Rice is becoming more and more common, and in the well-to-do homes, of course, bread and butter are

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213 Ibid.

214 Rockefeller Foundation, "Hookworm Infection Survey of the State of Pernambuco," (International Health Board, 1920), RAC RG 5 2_305 B25 F149.

215 Rose, "Public Health Situation," 22.

216 Placido Barbosa, "Translation of the Report on the Survey of the State of Minas Gerais" (International Health Board, 1919), RG 5 S2 B23 F135, RAC, 8.

> always to be found. Coffee takes the place of breakfast for the field workers, and only too frequently he gets no more than fish and manioc meal during the rest of the day.[217]

The same report indicated that the consumption of fresh milk is rare, and it was never served un-boiled. Further, green vegetables were rare and difficult to obtain. These general patterns were not true for German population, whose diet was generally more balanced.[218]

With continued improvements in transportation infrastructure throughout the twentieth century, as well as the emergence of refrigeration, these generalizations regarding regional dietary patterns became less applicable. Data from the earliest known nutritional survey in Brazil, which was carried out by the IBGE in 1975, appear in Table 6.3 in the Appendix. The survey breaks protein consumption down by regions and income groups to provide an insightful assessment of regional dietary patterns in the latter part of the twentieth century. The fact that industrial food production led to some convergence in dietary patterns is readily appreciable when we examine the consumption of proteins from meat and fish across regions. For all income groups, the proportion of proteins from meat and fish sources in the Northeast was just slightly lower than the same for São Paulo and the states in the South. For the lower and middle income groups, protein consumption from meats and fish was actually higher in the North than in any other region. Intriguingly, in both the North and Northeast, protein consumption from meats and fish was higher than in any other region amongst the low and middle income groups. Despite these facts, the amount of protein consumed from milk, eggs, and cheese

[217] Rockefeller Foundation, "Hookworm Infection Survey of the State of Santa Catarina, (International Health Board, 1920), RG 5 2_305 B25 F149; 44.

[218] Ibid.

was lower in the North and Northeast than in the other regions. This confirms that in aggregate terms, the diet in the North and Northeast continued to be inferior.

The Environment and Disease Dynamics

Water Scarcity and the Persistence of Poverty in Brazil's Northeast

In addition to their impact on local dietary patterns, diverse climatic conditions also exerted an influence on the biological standard of living in Brazil through the disease environment. Encompassing nearly 3.29 million square miles, the Brazilian territory is vastly dissimilar in terms of geography and weather regimes. In this section, I discuss the health outcomes related to extreme weather events, both in terms of water scarcity and overabundance. As discussed in the Introduction to this dissertation, rainfall patterns diverge vastly across Brazil's regions. To no surprise, the Northern states of Amazonas and Pará occupy the first and second places in the order of rainfall by state. At the other end of the spectrum, one observes the semiarid Northeastern states of the region commonly referred to as "the drought polygon"—Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas and Sergipe. Living conditions within the Northeastern drought polygon began to interest policymakers as early as the Great Drought of 1877-79. In his 1879 report to the emperor, the President of the Province of Alagoas, Cincinnato Pinto da Silva, spoke of the severe drought that had plagued many northeastern provinces:

> This horrible calamity that for two years has so cruelly afflicted some provinces in the north of the Empire has had little impact here. However, with an increasing number of refugees coming to this Province, mostly from the high *sertões* of Pernambuco and Paraíba, they were promptly aided with food and clothing, given the state in which they arrived—in addition to being exhausted from the long

> journey and trampled by hunger, [they were] in a state of almost complete nudity or covered in rags.[219]

This quotation from Pinto da Silva touches upon two important themes by which drought events influenced health and living standards in Brazil. First, social transfers to aid in overcoming the calamity rose, and this period was the only time in the nineteenth century that the imperial government ran a deficit. Secondly, Pinto da Silva highlighted the large amounts of migrants that moved to cities in the Northeast and elsewhere, constituting one of the first references from a public official on the push-factors of north-south migration in Brazil.

Policymakers became even more concerned with the consequences of recurrent droughts in the 1920s, and several surveys documented increases in food prices following the poor harvests of drought years.[220] In 1918, Dr. Octavio de Freitas remarked on the "brain drain" effects that the waves of drought had created in the predominantly rural state of Pernambuco: "Since agriculture is a fact of rural life, and since we are such a poor state of workers, due to the lack of immigration from abroad and the unregulated exodus of our children, I view it of the highest necessity to care for those few of us that stay behind in the fields fighting unflinchingly and undauntedly for our lives."[221] In this light, the recurrence of droughts has constituted a formidable obstacle to development in the interior of the Northeast. On the one hand, those that have remained in drought areas

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[219] Cincinnato Pinto da Silva, "Falla com que o exm. snr. dr. Cincinnato Pinto da Silva, presidente da provincia, installou a 2ª Legislatura Provincial das Alagoas em 30 de abril de 1879" (Maceió: Typographia do Liberal, 1879).

[220] Antonino da Silva Neves, *A Sêca de 1919* (Rio de Janeiro: Oficinas Gráficas do Jornal do Brasil, 1919).

[221] Octavio de Freitas, "Hygiene Rural," *Imprensa Nacional*, 1918.

saw debilitated health. On the other hand, events of water scarcity have resulted in the exodus of productive workers.

Anthropometric historians have studied the influence of extreme climatic events on stature. Amílcar Challú argues that drought events had a debilitating effect on stature in seventeenth-century México because they caused poor harvests and consequently increased grain prices.[222] In the case of Brazil, during the drought of 1919, Neves documented the highest food prices ever seen at the time.[223] However, in addition to the potential adverse effects on nutrition, water scarcity also has the potential to increase risk of enteric disease, many inhabitants have no other recourse but to obtain water from sub-standard sources. Rural inhabitants may take water from areas in which animals also drink, or in which animals have died. In addition, as lakes and ponds which were previously abundant in supply become reduced to puddles, the salinity of the water increases. In recent times of drought in the region, observers have noted an upsurge in the incidence of dengue fever, brought on the increase in the usage of water cisterns to capture rainwater (which are not properly managed to reduce the proliferation of mosquitos).

Although pluvometric indices are not available for the nineteenth century, anecdotal evidence on the occurrence of devastating droughts aids in determining the influence of climatic shocks on the biological standard of living.[224] Figure 6.10 below displays average stature by year of birth of soldiers residing in the Northeast drought polygon, along with vertical reference lines that denote debilitating drought events, from

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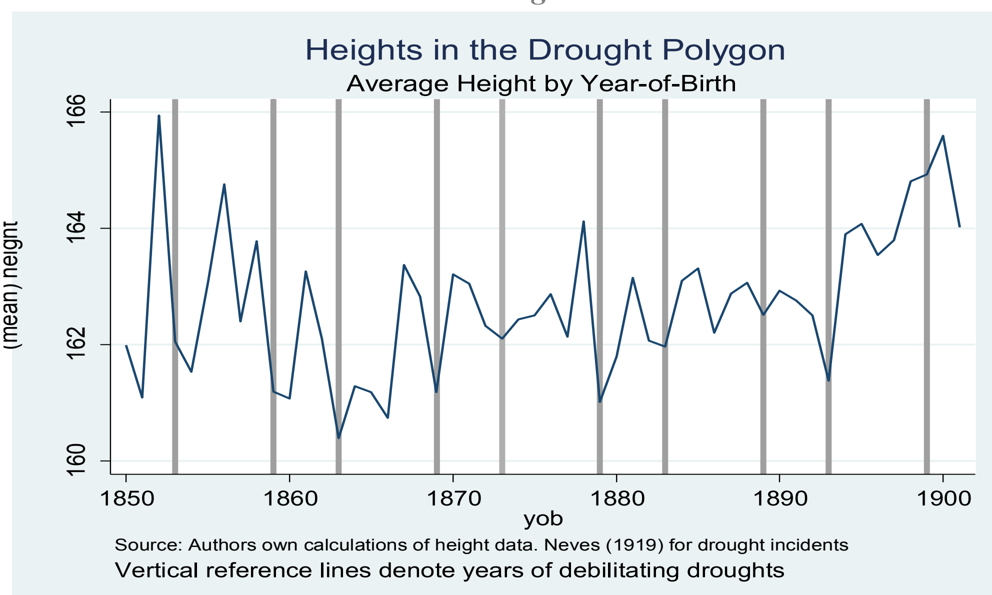
[222] Challú, "Agricultural Crisis and Biological Well-Being in Mexico, 1730-1835."

[223] Neves, *A Sêca de 1919*.

[224] Ibid.

1850 to 1900. Unfortunately, the reduced number of observations of soldiers hailing from the Northeast precludes constructing an annual heights series for the post-1900 period. As we can observe, throughout the nineteenth century drought events were associated with a decline in average stature of two to three centimeters. This finding seems consistent with contemporary studies on birth weight and rainfall fluctuations in the region which have documented an increase in birth weight of 1.9 grams with a 31 percent increase in rainfall.[225]

Figure 6.10



Climate Shocks, Floods, and Health

In order to gauge the effects of floods on heights, I exploit a subsample of the AHEX dataset that contains information on the municipality-of-birth of the soldier.[226] The objective of this section is to model the relationship between oscillations in rainfall

[225] R. Rocha and R. R. Soares, "Water Scarcity and Birth Outcomes in the Brazilian Semiarid.," *IZA Discussion Paper*, no. 6773 (July 2012).

[226] I thank Rodrigo Soares for providing the geocoded dataset of the Brazilian municipalities. See Joana Naritomi, Rodrigo R. Soares, and Juliano J. Assunção, "Institutional Development and Colonial Heritage within Brazil," *Journal of Economic History* 72, no. 02 (2012): 393–422.

and heights. As discussed in Chapter 2, enteric diseases constitute one major source of stunting of heights, and I hypothesize that we can model the risk of enteric disease in the year of birth by using historical climate data.[227] In the 1950s, researchers at the World Health Organization developed a conceptual framework to summarize the transmission channels of diseases resulting from human excreta.[228] Subsequently, public-health scholars modified Wagner and Lanoix's schema to illustrate the transmission pathways of diarrheal disease. Known as the F-Diagram, the schema describes five to six pathways starting with the letter "F" that spread enteric pathogens from human feces: fingers, fomites/flies, fluids, fields/floors, and foods.[229] Commonly added to the list of pathways are floods—the factor that the model below attempts to capture.

Based on the CRU climate dataset and the AHEX municipal-level subsample, I estimate OLS regressions of the following form:

$$\text{Height}=\beta_0+\beta_1\text{RainVeloc.}+\beta_2\text{Rainfall}+\beta_3\text{Temp}+\beta_4\text{Rugged}+\beta_5\text{Lat\&Lon}+\beta_6\text{ Age}+\beta_6\text{ YOB FE}+\varepsilon$$

where height is the dependent variable; β_0 is the constant; β_1 the average velocity of rainfall is the predictor variable of interest; variables β_2 through β_6 control for total rainfall, temperature, ruggedness, location, and young ages; and ε is the error term.

The predictor variable of interest is rainfall velocity, since this likely impacts the propensity for flooding. I computed this variable by dividing the total amount of rainfall in a given month by the number of rainy days registered in that month to give a crude sense of the intensity of precipitation. I include average rainfall as a control variable since

[227] I. Harris et al., "Updated High-Resolution Grids of Monthly Climatic Observations – the CRU TS3.10 Dataset," *International Journal of Climatology* 34, no. 3 (March 2014): 623–42.

[228] Edmund G. Wagner and J. N. Lanoix, "Excreta Disposal for Rural Areas and Small Communities," *World Health Organization Monograph Series*, no. 39 (1958).

[229] Jeff Conant, "Sanitation and Cleanliness for a Healthy Environment" (Hesperia Foundation & United Nations Development Program, 2005), www.unwater.org.

it could potentially be related to population size or income. Temperature controls for the influence of temperature on the spread of bacteria. Ruggedness, as proxied by the standard deviation of elevation in the municipality, is also included, since less rugged or flatter municipalities likely saw reduced groundwater flow rates.[230] Continuous controls variables for geographic location, latitude and longitude, account for local factors that could influence the potential for flooding. Age controls take into account the fact that those under the age of 23 may not have reached terminal adult height. Additionally, I use dummy variables for the year of birth to account for time-varying influences on height outside of the model, such as income oscillations.

The summary statistics for the climatic variables used here are found in Table 6.1. I opted to isolate only the summer months for regression analyses since rainfall is most abundant in Brazil during the summer, and I hypothesized that the risk of enteric disease would be greater during that period. The AEDS for Rio de Janeiro discussed above disaggregates certain diseases by month of the year, and the available statistics on the incidence of gastrointestinal disease in Rio de Janeiro confirm this suspicion.

Table 6.1

Summary Statistics for the AHEX & CRU Subsample					
Variable	**N**	**Mean**	**Std. Dev.**	**Min**	**Max**
Height	6994	167.7495	5.867466	154	192
Height Pre-1915	1461	166.6961	6.402753	155	190
Height Post-1915	5427	168.0079	5.672189	154	188
Avg. Summer Rain Velocity	7068	7.172303	2.142746	0.663435	17.53322
Avg. Summer Rainfall	7068	169.7963	72.36737	10.075	430.9
Avg. Summer Temp	7068	23.87279	2.124044	17.8	28.975
Std. Dev. Elevation	7008	102.7112	70.11386	0	462.2425
Longitude	7068	-44.6277	5.066616	-68.2648	-34.8568
Latitude	7068	-19.114	6.869508	-32.4036	0.07317

230 Data extracted with GIS.

Regression results are summarized in Table 6.2. The first specification includes all of the soldiers with municipality of birth listed in the AHEX documentation (n=6,935). Overall, this model predicted 0.068 of the variation in individual stature. The coefficient for average summer rainfall velocity is statistically significant and negative as we would expect, b = -.192 ($p < .05$), implying that an increase in rainfall intensity in the year of birth had a negative impact on stature of approximately 0.41 centimeters. In general terms, this might appear to be a small effect since the standard deviation of heights is 5.86. However, since this model is specific to the year of birth, we can consider such a reduction in stature to be substantial in terms of magnitude.

Table 6.2

OLS Regression Results Relating Heights (AHEX Sample) and CRU Climate Data

Dep. Var.:	1		2		3	
Height	Total		Born Pre-1915		Born Post-1915	
IVs						
Avg. Summer Rain Velocity	-0.192**	(0.07)	-0.446***	(0.17)	-0.0266	(0.09)
Avg. Summer Rainfall	0.00689***	(0.00)	0.0176***	(0.01)	0.00183	(0.00)
Avg. Summer Temp	0.113*	(0.06)	0.146	(0.17)	0.0982	(0.07)
St. Dev. Elevation	-0.00144	(0.00)	0.00514	(0.00)	-0.00240*	(0.00)
Longitude_	-0.0499**	(0.02)	-0.0995	(0.07)	-0.016	(0.02)
Latitude	-0.154***	(0.02)	-0.172**	(0.08)	-0.129***	(0.02)
age17	-0.933	(0.75)	-4.710***	(1.04)	-0.239	(0.82)
age18	-1.500**	(0.62)	-2.870**	(1.32)	-0.636	(0.52)
age19	-0.104	(0.29)	1.382	(0.84)	-0.127	(0.32)
age20	-0.592**	(0.27)	-2.245**	(0.93)	-0.257	(0.31)
age21	-0.47	(0.35)	-0.951	(0.74)	-0.169	(0.35)
age22	-0.654**	(0.29)	-2.009***	(0.60)	-0.202	(0.35)
YOB FE	Y		Y		Y	
Constant	159.2***	(1.82)	156.3***	(4.64)	162.9***	(2.16)
Observations	6,935		1,445		5,385	
R-squared	0.068		0.165		0.037	
Robust standard errors in parentheses						
*** p<0.01, ** p<0.05, * p<0.1						

The second and third specifications parse the municipality-level sample by sub-periods in order to identify time-varying effects of rainfall intensity. Since the decade of the 1910s marked the beginning of rural health work in Brazil, I used the year of 1915 as the inflection point. If the coefficient for rainfall intensity varies between the two specifications (for those born before and after 1915), then it is reasonable to conclude that interventions in sanitation accounted for a large portion of the increase in aggregate heights observed in Chapter 4. In the second specification, I consider only soldiers born before 1915. The coefficient for the summer rainfall velocity is negative and highly statistically significant, $b = -0.446$ ($p < .01$). This signifies that an increase in summer rainfall velocity of 1 standard deviation (or 2.14 mm/day) caused a reduction in stature of approximately 0.96 centimeters, a much larger effect than the one identified in the full model. Intriguingly, the effect for rainfall velocity disappears in the final specification, which considers only those soldiers born after 1915. This evidence points to a radical improvement in the disease environment.

6.4 Conclusion

This chapter discussed the height trends presented in Chapters 4 and 5. As we have seen, the military dataset appears to provide the most accurate vision of Brazil's historical height trends. In comparing the trends of Brazil with other nations, we saw that the upward trend in heights in the 1880-1910 period was large by international standards.

I argue that income growth and the earlier initiation of public-health reforms explain the upward height trends in Brazil's southern regions, while the latter was most crucial for the northern territories in which income growth was less accentuated and the epidemiological environment was more severe. Furthermore, I suggest that Brazil's long-term health inequities between regions reflect geographic endowments underpinning both the epidemiological environment and regional discrepancies in dietary patterns, rather than socio-political factors.

Regression results modeling the risk of enteric disease with historical climate data show that the effect of flooding, with rainfall intensity as a proxy measure, had a significant and negative impact on stature. This effect was identified in the entire municipality-level subsample, but it was far more severe for soldiers born prior to 1915—a major inflection point in Brazilian public-health policies as it marked the emergence of rural health initiatives. The negative effect of rainfall velocity on stature disappears for soldiers born after 1915, suggesting that a radical improvement in sanitation took place. In the next chapter, I examine hookworm disease, the rollout of rural health institutions, and their effects in greater detail.

Appendix

Table 6.3

Nutrition Indicators: 1975 Consumption of Proteins by Meal/Day & Food Group; all values in grams (g)								
Income Group & Region	Total	Cereals	Tubers	Legu-minous	Vege-tables	Fruit	Meat & Fish	Eggs, Milk, Cheese
Rio de Janeiro								
All	67.58	19.89	1.1	12.28	1.25	0.66	22.97	8.46
Low	46.03	18.07	0.97	13.15	0.66	0.22	9.31	3.08
Mid.	62.64	20.55	1.01	13.4	1.05	0.5	18.93	6.44
High	82.99	20.37	1.24	10.95	1.73	1.02	33.45	12.91
São Paulo								
All	65.84	21.01	0.74	12.46	1.31	0.59	19.5	9.16
Low	46.75	19.56	0.52	14.17	0.66	0.14	7.04	3.99
Mid.	61.79	22.02	0.68	14.06	1	0.4	15.56	7.15
High	77.72	20.96	0.89	10.51	1.85	0.93	28.18	13.03
South (Paraná, Santa Catarina e Rio Grande do Sul)								
All	71.88	25.96	1.6	13.76	1.03	0.37	19.28	8.93
Low	57.13	23.28	1.35	17.11	0.67	0.17	9.36	4.5
Mid.	75.73	28.43	1.81	13.77	1.06	0.36	19.77	9.57
High	86.84	26.34	1.67	9.22	1.47	0.66	32.11	14.12
Center (Minas Gerais & Espirito Santo)								
All	58.62	20.43	1	16.89	1.04	0.41	11.99	5.97
Low	50.51	18.92	0.96	19.35	0.88	0.25	6.06	3.3
Mid.	62.33	22.25	1	15.55	1.1	0.43	14.4	6.71
High	74.79	22.03	1.07	12.3	1.38	0.81	24.07	11.86
Northeast (Maranhão, Piauí. Ceará, Rio Grande do Norte, Paraiba, Pernambuco, Alagoas, Sergipe, and Bahia)								
All	60.99	13.21	2.59	21.42	0.4	0.51	18.05	4.21
Low	55.57	11.21	2.77	22.97	0.29	0.38	14.44	3.03
Mid.	72.77	18.52	2.23	18.37	0.58	0.75	25.62	5.89
High	84.32	20.18	1.78	14.24	0.97	1.11	34.08	10.87
North & West (Rondônia, Acre, Amazonas, Roraima, Pará, Amapá. Mato Grosso e Goiás)								
All	60.34	17.03	1.5	9.19	0.65	0.56	25.76	4.83
Low	46.6	13.81	1.61	8.65	0.34	0.3	19.16	2.19
Mid.	61.31	17.88	1.58	9.84	0.62	0.54	26.14	3.92
High	75.87	20.02	1.29	9.15	1.07	0.91	33.33	8.98
Income Classes: Low: <Cr$ 2 260 | Middle: Cr$ 2 260--Cr$ 4 519 | High: >Cr$ 4 520								
Notes: Omitted from the table: Brasília and columns pertaining to Drinks, Fats, and Sugars.								
Source: IBGE, Anuário estatístico do Brasil 1979. Rio de Janeiro: IBGE, v. 40, 1979. Accessed at www.ipeadata.gov.br								

Table 6.4

Regressions Considering the Effect of Commodity Prices on Heights (AHEX Sample)

Coffee States	**1) Dep. Var: Heigh**	Coef.	Std. Err.	P>t	**N**	4661
	_cons	166.276	.2703538	0	**R-squared**	0.0187
	price_coffee	0.124058	.0760881	0.103	**Adj R-squared**	0.017
	Age Controls	Y				
	2) Dep. Var: logHeight					
	_cons	5.113834	0.001575	0	**N**	4661
	logprice_coffee	0.0012	0.001274	0.347	**R-squared**	0.0188
	Age Controls	Y	0.004299	0.754	**Adj R-squared**	0.0172
Sugar States (NE)						
	3) Dep. Var: Height					
	_cons	162.6792	0.213562	0	**N**	5739
	price_sugar	0.030188	0.013322	0.023	**R-squared**	0.0322
	Age Controls	Y			**Adj R-squared**	0.0308
	4) Dep. Var: logHeight					
	_cons	5.091803	0.003507	0	**N**	5739
	logprice_sugar	0.000653	0.001346	0.627	**R-squared**	0.0314
	Age Controls	Y			**Adj R-squared**	0.0301

Chapter 7. Brazil's Hookworm Hurdle

Introduction

The objectives of this chapter are to describe the burden of hookworm infection in early-twentieth-Brazil, highlight the advances in tropical medicine that facilitated the identification and prevention of the disease, and evaluate the impact of hookworm-eradication campaigns conducted in Brazil from 1916 through 1923. Affecting nearly 2 billion persons in the world today (approximately one-quarter of the global population), soil-transmitted helminthic infections such as hookworm continue to be a major hindrance to economic and social development. The most readily-observable symptoms of hookworm are lethargy and anemia, and observers often remark on the limited productivity of those infected with the disease.[231] While the present-day occurrence of hookworm is more confined than it once was, afflicting mainly tropical and sub-tropical climates in Sub-Saharan Africa, the Americas, and Asia, in the late-nineteenth and early-twentieth centuries the disease reached a more widespread global scope. Prior to interventions targeting rural sanitation in the early-twentieth century, hookworm plagued roughly half of the population living in the Southern United States.[232] Established with funds donated by John D Rockefeller, Sr. in 1909, the Rockefeller Sanitary Commission for the Eradication of Hookworm Disease (RSC) initiated rural health campaigns in the US that would address this grave situation. Subsequently, the International Health Board

[231] Hoyt Bleakley, "Disease and Development: Evidence from Hookworm Eradication in the American South," *Quarterly Journal of Economics* 122, no. 1 (February 2007): 73–117.

[232] Rose, W. "Notes on Hookworm in the US South, 1913." RF 5 3_200, B5 F43.

(IHB) would go on to implement similar hookworm-eradication methods on an international scale.[233]

This chapter intervenes in two dominant trends in the related literature. The first relates to the general historical scholarship on the Rockefeller Foundation's health work, and the second concerns the historiography on Brazil's First Republic (1889-1930). With respect to the former, despite a record of successful interventions, historical analyses of the public-health efforts of the IHB tend to fall into two camps. One branch of scholarship views the health campaigns orchestrated by the IHB as purely altruistic deeds that sought to benefit humankind, while others condemn the IHB's public-health activities as mechanisms imperialistic domination. While there are studies that eschew these dichotomous orientations altogether, few historians interested in disease or tropical medicine have endeavored to evaluate the consequences of IHB-led interventions with direct evidence on local population health. To that end, this chapter hones in on the anti-hookworm work of the IHB in Brazil, analyzing rural hygiene efforts in conjunction with evidence on the heights of Brazilian soldiers.

Although much of the historiography on Brazil assumes that living conditions for the masses failed to improve during the First Republic, in the early-twentieth century I reveal a stature increase in Brazil commensurate with that observed in more industrialized nations in the same period.[234] This chapter will rely on reports of the IHB in Brazil in order to

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[233] Based on the model of the Rockefeller Sanitary Commission, the Rockefeller Foundation's International Health Commission (IHC) was established in 1913. Later, this entity was renamed the International Health Board (IHB) in 1916, and then moved on to be called the International Health Division (IHD) in 1927. For simplicity, unless otherwise noted, I use the term IHB as it was applied to the commission during the anti-hookworm work in Brazil.

[234] Steckel and Floud, *Health and Welfare during Industrialization*.

demonstrate that de-worming activities improved health conditions and expanded investments in public-health institutions.

Heights offer a particularly valuable insight into population health in Brazil before 1940, when records on other population-health indicators become more abundant. Due to the disease's propensity to stunt musculoskeletal development, information on stature is also of tremendous importance when evaluating the burden of hookworm faced by a population. In the early-twentieth century, hookworm infection rates in Brazil became more accentuated in ages in which children entered into agricultural labor (typically around age 12), and I indicate that hookworm impeded the adolescent growth spurt for many rural inhabitants. I present evidence of severe stunting of soldiers before 1910, and I find a large increase in heights-by-age after the hookworm-eradication efforts. This increase in stature was much more accentuated in areas of Brazil with the highest levels of infection. This chapter argues that, in addition to being crucial in disseminating the medical knowledge necessary to identify and control hookworm infection, the IHB's activities in Brazil catalyzed the expansion of the local government's public-health sector and significantly improved health conditions.

The argument proceeds in 5 sections. Section 7.1 describes the ecology and detrimental effects of hookworm, and Section 7.2 discusses previous scholarship on the Rockefeller Foundation's health work. Section 7.3 details the work of the IHB in Brazil, synthesizing the findings of the Board's hookworm surveys and highlighting modifications to eradication methods applied elsewhere in order to fit the country's inhospitable geography and relative lack of transportation infrastructure. Section 7.4 presents evidence on the public-health expenditures of Brazilian authorities and the heights of Brazilian soldiers before and after the intensive hookworm campaigns. In addition to highlighting the success of anti-hookworm measures in early-twentieth-century Brazil, this section also pinpoints economic, social, and cultural factors that curtailed to effectiveness of such measures. Section 7.5 concludes.

7.1. Hookworm: Disease, Ecology, and History

Although the disease rarely results in death (and hence its burden is difficult to ascertain based on mortality statistics) hookworm severely debilitates and limits the productivity of those infected. One of several types of soil-transmitted helminthic infections, hookworm disease, or ancylastomiasis, is caused by intestinal parasites. Two types of parasitic worms, the *necator americanus* and *ancylostoma duodenale*, can cause infection with hookworm. In humans, hookworm infection can have devastating consequences. The worms feed on the blood of humans, thus decreasing the amount of iron and protein available for homeostasis and musculoskeletal development. By diverting nutrients away from 'normal' physical growth and body functions, hookworm tends to both stunt growth and provoke immunodeficiency. Typical symptoms of hookworm infection include severe fatigue, loss of appetite, and iron-deficiency anemia. In addition to direct effects of nutritional malabsorption, hookworm in adolescents and children can also stunt growth due to the onset of diarrhea in cases of severe infection.[235]

Although it is possible to ingest the more pathogenic *ancylostoma duodenale*, the most common mode of transmission is penetration of the skin. Once eggs are released into favorable soil conditions (with ample humidity, moderate warmth, and some shade), they grow and hatch into rhabditiform (non-infective) larvae in one to two days. After

[235] John Ettling, "Hookworm Disease," in Kiple, Kenneth F. (ed.) *The Cambridge World History of Human Disease* (Cambridge Histories Online), 784-788.

five to ten more days, these non-infective larvae grow into filariform (infective) larvae, capable of surviving in the soil for three to four week under suitable climatic conditions. Historically, the most common route of infection in humans has been through penetration of the skin of the feet. Upon entering a human host, the larvae travel through the bloodstream to the lungs, pass through the respiratory system, and enter into the esophagus. The larvae then enter the digestive tract, attach to the mucosa of the small intestine, and feed on the host's bloodstream. Once full grown after six to eight weeks, hookworms measure 1 cm in length. Adult hookworms can survive in humans for one to five years, and adult females daily release thousands of ova via the feces, allowing ample opportunity for proliferation and re-infection, thereby restarting the hookworm cycle. Populations residing in areas in which outdoor defecation is prevalent, footwear is scarce, and climatic conditions are suitable run a high risk of being infected by hookworm.[236]

7.2. Previous Scholarship on the Rockefeller Foundation's Health Work

Although hookworm continues to challenge public-health officials, the prevalence of this disease was greatly curtailed by the philanthropic work of the Rockefeller Foundation in the early-twentieth century. In 1909, John D. Rockefeller created the Rockefeller Sanitary Commission (RSC) with a sum of roughly $1 million, and the RSC embarked on an elaborate anti-hookworm crusade in 11 of the southern US states. Over 5 years, the RSC conducted intensive hookworm eradication campaigns,

[236] Garland L. Brinkley, "The Decline in Southern Agricultural Output, 1860-1880," *Journal of Economic History* 57, no. 1 (March 1997): 116–38.

which entailed aggressive de-worming measures and latrine construction.[237] After successfully reducing the burden of hookworm in the US South, the Malay States, and other parts of Asia, the IHB shifted its efforts to the Americas. From 1916 through 1922, the IHB led intensive eradication campaigns throughout Brazil, sponsoring ambulatory dispensaries that provided de-worming treatments and awareness campaigns that alerted rural residents and local physicians of the detrimental effects of hookworm as well as the methods to prevent infection.

Many historians view the public-health efforts of the Rockefeller Foundation's International Health Board (IHB) as either purely altruistic endeavors or mechanisms of imperialistic domination. Scholarship on the public-health work conducted by the IHB is generally limited to qualitative assessments by historians of medicine, on the one hand, and economic historians and epidemiologists conducting quantitative evaluations with semi-experimental research frameworks, on the other. Covering much more than hookworm, Farley examines the work of the IHB in global perspective. According to Farley, the Rockefeller Foundation directors saw hookworm as an excellent opportunity for the IHB to enter into foreign territories and conduct intensive campaigns in rural areas, thus illustrating to local governments the benefits of modern health institutions. Farley argues that the role of the IHB as a catalyst to spark increased health investments by local governments never came to fruition. As this chapter reveals, in the case of Brazil, Rose's vision appears to have materialized.[238]

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[237] Bleakley, "Disease and Development: Evidence from Hookworm Eradication in the American South."

[238] John Farley, *To Cast Out Disease: A History of the International Health Division of the Rockefeller Foundation, 1913-1951* (USA: Oxford University Press, 2004).

In Latin America in particular, Birn studies the work of the IHB in Mexico, yet aside from information on the number of treatments, this scholar provides no indications as to the effectiveness of the public-health work in the nation. Birn's analysis provides speculations that the IHB was so influenced by its relationship with Mexico that it set the tone for future philanthropic medical interventions throughout the world.[239] Given the long relationship between the IHB and Brazil, we could question the validity of that assertion. While a worthy contribution to the history of public-health institutions in Latin America, Birn's analysis fails to examine the outcomes of public-health endeavors for the local population.

Economic historians interested in policy evaluation have also exploited interventions led by the Rockefeller Foundation in semi-experimental frameworks.[240] Analyzing the long-term consequences of rural hygiene, in contrast to many qualitative researchers, Bleakley finds that the anti-hookworm services of the RSC significantly increased income and school enrollment. Historians working on topics related to medicine and population health in Latin America have traditionally lacked the quantitative abilities necessary to evaluate the effectiveness of health interventions, and long-term considerations related to economic development have not been sufficiently studied in the region. It is a pity that quantitative historians and historians of medicine have had limited interdisciplinary dialogue, since researchers in both fields stand to gain much from more collaborative insights.

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[239] Anne-Emmanuelle Birn, *Marriage of Convenience: Rockefeller International Health and Revolutionary Mexico* (Boydell & Brewer, 2006).

[240] See Bleakley, "Disease and Development: Evidence from Hookworm Eradication in the American South."

The intensive hookworm-eradication campaigns spearheaded by the IHB consisted of curative and prophylactic measures. Remedial techniques involved treatment with a de-worming agent. In the early stages of the hookworm eradication campaigns in the US, the most commonly used anti-parasitic was beta-naphtol. Subsequently, physicians commonly used other deworming agents, such as thymol and oil of chenopodium. The latter of these, which was consequently the cheapest, was most frequently deployed in the Brazilian campaigns. Depending on the age and worm-load of the infected patient, a series of de-worming treatments were used, followed by a dose of Epsom salts as a purgative. In terms of prevention, the IHB advocated for increased use of footwear and soil sanitation, encouraging heads of family and land- and business owners to construct latrines.[241]

7.3. The IHB and Hookworm Eradication in Brazil, 1916-1924

Early stages

In 1916, Wickliffe Rose, Director of the IHB, contacted the director of public health in Brazil in order to solicit information on the extent of infection in the country. Officials from the state of Rio de Janeiro accepted the call and invited the IHB to come to Brazil, and subsequently many states also entered into contract with the Board as well. In general, the goal was to select towns of small population in order to examine a large percentage of the inhabitants and avoid the error which might arise in larger towns by the examining an unintentionally selected group, as could occur if only those with anemic

[241] Wickliffe Rose, "No. 7302, Observations on Public Health Situation and Work of the International Health Board in Brazil." New York, 1920. RAC RG 5 3_305 B107 F1401; 22.

symptoms presented themselves for examination and free treatment.[242] Moving from one town to the next, one nurse would have a small lab to demonstrate hookworm prevalence with microscopes. These lantern presentations were announced before arrival of the IHB personnel and then carried out on the first day of operations. Physicians showed slides of hookworms, their ova, and the manner of infection. Then, the presenter would speak of the IHB; why and how the work was done for free; hookworm disease itself; and the value of exams to the Brazilian people. The speaker would conclude by offering free treatment to all found to be infected.[243]

Among the first states to receive the IHB were Rio de Janeiro and São Paulo in 1916. On the first survey in Rio de Janeiro state, Hackett drew attention to the lack of sanitary latrines in many rural areas and the pervasiveness of hookworm in communities lacking sanitation. For example, in Parahyba do Sul, a town that had a sewer system in place for 30 years prior to the IHB survey, the rate of hookworm infection was 70.1 percent. In São João da Barra, a coastal municipality with no sewers but some use of latrines, the rate of infection was 89.4 percent. In Ararauma, a locale with no sewage and few latrines, the rate of infection was 92.3 percent.[244] Hackett concluded the report of this first survey by highlighting the social and economic consequences of the severity of hookworm infection and calling for immediate action to redress the grave situation:

> It seems clear that no amount of economic regulation or system of governmental subsidies will be able to accelerate the evolution of a new order of agricultural and industrial

[242] L. W. Hackett, M.D. "Hookworm Infection Survey of the State of Rio de Janeiro, Brazil." IHB: NY, 1918. RG 5 3_305, B111, F1432; 10.

[243] J. L. Hydrick, M.D. "Report No. 7468 Hookworm Infection Survey of the State of São Paulo, Brazil." (International Health Board: New York, 1919). RG 5 2_305, Box 23 Folder 139; 15.

[244] Ibid.

> efficiency so surely and at the same time so cheaply as a wise and vigorous attempt to improve the health of the laboring classes and the sanitary conditions under which they work and live. Since 90 per cent of this class are infected with hookworm, and suffer thereby both a loss of efficiency, conservatively estimated at 20 per cent, and a diminution of resistance to other diseases, both chronic and infectious; since infected mothers cannot bear strong and healthy children to become the future workers of the state, and since infected children are known to be retarded physically and intellectually, and are thus doubly handicapped in life's struggle—the value of Dr. Osorio's advice to begin as soon as possible a concerted attack against this insidious disease [...], becomes self-evident.[245]

After the first survey in Rio de Janeiro, hookworm-eradication campaigns were carried out in 11 of Brazil's 20 states: Alagoas, Bahia, Espírito Santo, Maranhão, Minas Gerais, Paraná, Pernambuco, Rio de Janeiro, Rio Grande do Sul, Santa Catarina, and São Paulo.

The apex of hookworm-eradication efforts came in 1919, when the IHB was active in over 89 counties. On a visit to Brazil in 1919, Director Rose commented on the severity of infection in Brazil:

> With respect to the former, state-wide surveys based on microscopic examination covering all parts of the country, and reinforced by extensive worm counts in more than twenty representative localities, have shown that hookworm infection is prevalent throughout the country; that practically no one living under rural conditions escapes it; and that among agricultural laborers, particularly, it is a serious menace to life and health and working efficiency. The head of the Federal Division of Rural Prophylaxis estimates that hookworm infection, as a menace to rural health, outranks all other diseases combined.[246]

Anecdotal accounts such as Rose's make clear that hookworm infection had debilitating economic consequences in Brazil by limiting productivity in agriculture.

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245 Ibid.

246 Wickliffe Rose, "No. 7302, Observations on Public Health Situation and Work of the International Health Board in Brazil," (New York: IHB, 1920), RAC RG 5 3_305 B107 F1401; 22.

Modification of the intensive method

Although in the outset the IHB maintained preexisting hookworm-eradication methods, the vast territorial expanse, difficult topography, and lack of transportation infrastructure encountered in Brazil required several modifications to the intensive method. Further, innovations in medical knowledge regarding the identification of the disease, compounded with a lack of laboratory equipment and properly-trained microscopists, prompted the use of alternative methods to determine the extent of hookworm infection. In his 1917 report on the IHB's progress in Brazil, Hackett stated: "Up to the end of the year the intensive method has been strictly adhered to, although the conditions for its employment are much less favorable, owing to the sparseness of the population, than those in the countries where the method was evolved."[247] It became apparent that changes would have to be made in order to reach the sparsely distributed rural population of Brazil.

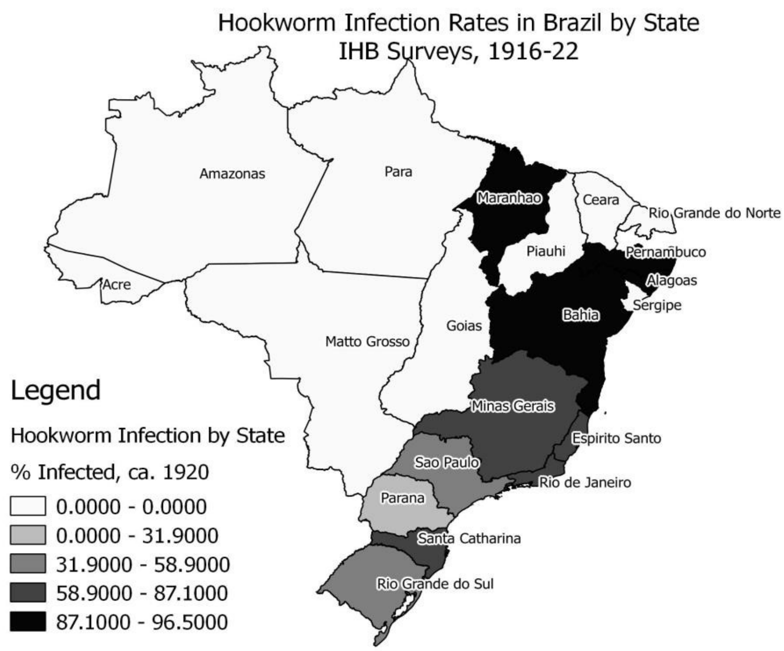
The following modifications were made to cope with these obstacles. First, as beta-naphtol was prohibitively expensive in Brazil, oil of chenopodium was the de-worming treatment of choice. Second, in addition to being costly, in 1919 Dr. Smillie discovered that margins of error in determining the degree of infection by microscopic stool examination was on the order of 15 percent. Thus, patients with very low worm loads could go unnoticed even by the most expert microscopists. Clinicians in Brazil also took hemoglobin levels using the Talquist scale. However, even when accounting for comorbidity of malaria, Smillie revealed that the number of hookworms in Brazilian patients had very little bearing on the hemoglobin levels determined by the Talquist scale

[247] Hackett, LW. "Relief and control of uncinariasis in Brazil for the year ending December 31, 1917." (New York: IHB, 1918), RAC RG 5 2_305, B23 F139.

(the normal error of which is itself normally superior than 10 percent). The IHB reports have several mentions of a "low normal" hemoglobin level in Brazilian patients, pointing to enduring problems with micronutrient consumption.[248] Lastly, rather than monitor patients until worm loads reached 0, medications were distributed to patients directly. In areas in which initial microscopic exams indicated infection rates superior to 85 percent, the microscope was abandoned under the presumption of near-universal infection.[249]

Regional Variation in Infection and Eradication

Figure 7.1



[248] W. Rose, "Observations on Public Health Situation and Work of the International Health Board in Brazil" (New York: IHB, 1920), RAC RG 5 3_305 B107 F1401; 22. "Climate, intestinal parasites, and in some localities, malaria, have contributed to this result. In the towns and cities syphilis also has to be taken into account. There can be no reasonable doubt that the low vitality is the chief underlying cause of the high tuberculosis rate referred to above and that it plays and important role in the high infant mortality. Blood tests and observations on a large scale, in regions where malaria is not prevalent, where venereal infections are presumably not considerable, and where the people have been freed from their intestinal parasites, have led to the recognition of a low "normal hemoglobin index" as standard for the country."

[249] See RAC RG 5 3_305, B112 F1438; 210.

While hookworm was a pervasive public-health problem throughout the Brazilian territory, the extent of infection was substantially less in the country's Southern regions. Of the 11 states of Brazil that entered into cooperation with the IHB and received intensive hookworm eradication campaigns, the Northeastern state of Maranhão displayed the highest level of infection, 96.5 percent of the population surveyed. Alagoas and Pernambuco were not far behind, with 94.5 and 93.4 percent infected, respectively. Table 7.2 in the Appendix to this chapter contains information on other areas surveyed by the IHB in the early-twentieth century. Only rural regions in Colombia (96 percent) and Panama (97 percent) had comparable levels of infection. However, it should be noted that these surveys were limited in geographic scope compared to those done in Brazil. Therefore, it is safe to assert that the Northeast of Brazil had some of the most elevated hookworm infection rates in the world (if not, the most elevated).

Survey reports shed light on factors that underpinned the regional variation in hookworm infection rates. Geography was of the utmost importance in determining the ability of hookworm ova to hatch in soil and (re)infect individuals. Localities with less sandy and less absorbent soils had lower infection rates.[250] The type of agriculture predominating in key areas also influenced the degree of infection. Coffee plantations, it was suggested, were especially propitious because they provided a good deal of shade, allowing soils to maintain their moisture and facilitate maturation of the hookworm ova.

The importance of sewage is abundantly clear. Hackett draws attention to distinctions made between municipalities with different human waste disposal systems. In Parahyba do Sul, a town that had a sewer system in place for 30 years prior to the IHB

[250] Hydrick, "Hookworm Infection Survey of the State of São Paulo" (New York: IHB, 1917), 31.

survey, the rate of hookworm infection was 70.1 percent. In São João da Barra, a coastal municipality with no sewers, the rate of infection was 89.4 percent. In Araruama, a locale with no sewage and few latrines, the rate of infection was 92.3 percent.[251]

Preventative measures of the IHB in Brazil were often thwarted by high levels of poverty and the costs to constructing acceptable latrines. In the Northern regions surveyed, reports cite that acceptable latrines cost up to three times the value of the average home. One observer in Pernambuco stated:

> Lack of proper housing facilities and low standard of living are responsible for many of the health problems of Pernambuco. A family living in a thatch roofed mud hut cannot be made to see the wisdom of installing a sanitary latrine, costing perhaps three or four times what their home cost. The same is true of piped water, electricity and decent furniture. Furniture is very costly and is little used in the poorer homes.[252]

7.4. Consequences of Hookworm Eradication

Public-Health Expenditures

Contrary to what has been suggested by previous authors, the involvement of the IHB in Brazil did spur a substantial amount of investment in public-health work. By 1919, 8 out of 21 states were already cooperating with IHB. In addition, the federal government and individual states invested significant amounts themselves, independent of the IHB monies. Brazilian policymakers were so awakened to the necessity to sanitize rural areas that the Vice Consul in Rio stated that it was perhaps the country that had done most to address the grave hookworm problem:

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[251] Hackett, "Hookworm Infection Survey of the State of Rio de Janeiro" Rio Survey, RG 5 3_305, B111, F1432; 15.

[252] "Hookworm Infection Survey of the State of Pernambuco" RG 5 2_305, B25, F149; 14.

In all, then, it may be calculated that the total amount to be expended on rural sanitation during 1919 in Brazil will reach the impressive sum of 4.600:000$000 ($1,150,000.00 US currency), which is perhaps more, in proportion to the population, than any other country in the world is doing at present.[253]

Figure 7.2

Per Capita Appropriations of Individual States for Health Work, 1916-22 (Period average in milreis)

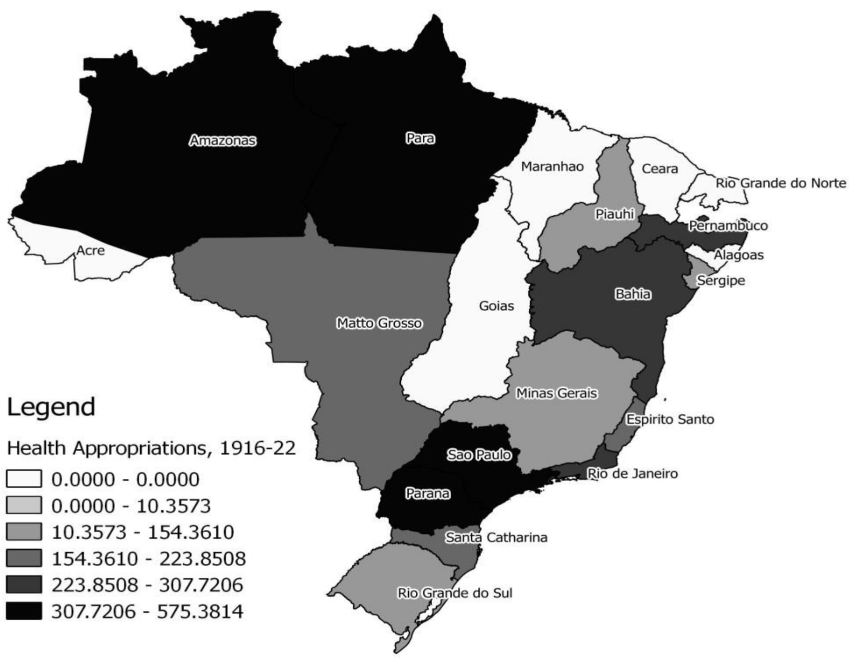


Figure 7.2 demonstrates the degree of variability in per capita appropriations by the individual states for rural health work between 1916 and 1922.[254]

Heights of Soldiers

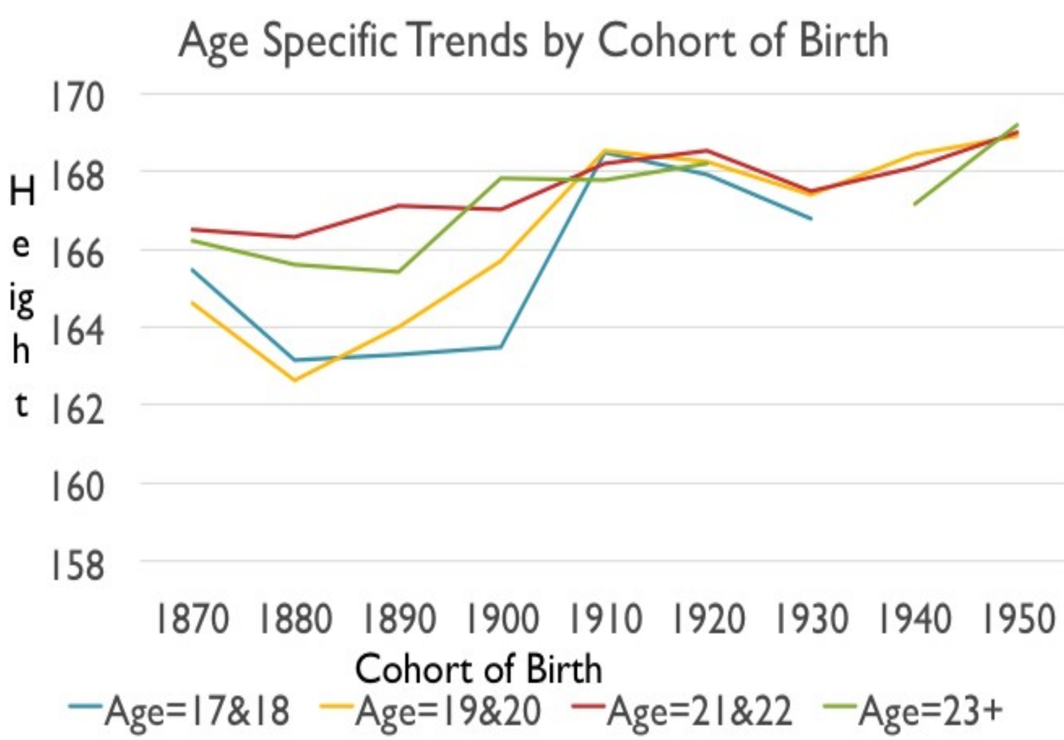
Statistics on heights-for-age are a reliable metric for health status. Hookworm disease during the adolescent growth spurt is known to cause stunting of growth, and the

[253] Augustus I. Hasskarl, American Vice Consul, "No. 7436, Copy of Statement on Hookworm Disease in Brazil and Rural Sanitation in the Suburbs of Rio de Janeiro." Rio de Janeiro, Brazil. April 7, 1919; RG 5 2_305 B25 F155; 3.

[254] Rockefeller Foundation, "Annual Report for Brazil, 1922." RG 5 3_305 B108 F1403.

IHB reports indicate that infection rates increased drastically in boys around the age of 11-12 years, when it was common for them to begin laboring in the fields. Figure 7.3 presents the heights of soldiers under the age of 23, before they would have attained their maximum adult height. We can see a substantial improvement in height-for-age averages for those ages consistent with the Rockefeller IHB rural sanitation interventions.

Figure 7.3



Source: AHEX dataset.

7.5. Conclusion

In addition to utilizing archival records of the IHB to describe infection rates and the hookworm-eradication campaigns throughout Brazil, this chapter also marshals evidence on human health culled from Brazilian archival materials to assess the outcomes of these measures. In relation to previous studies, three noteworthy findings stand out in the present chapter. First, although hookworm ravaged rural populations throughout the Brazilian territory, infection rates in the North and Northeast surpassed those of any other locale surveyed by the Rockefeller Foundation in the early-twentieth century. Secondly, in contrast to inferences made in the existing historiography, hookworm eradication did prompt an increased level of state involvement in health work while the IHB was present in Brazil and after the organization withdrew from the country. Thirdly, although de-worming initiatives improved the health status of the Brazilian population, persistent poverty continued to plague the nation by limiting household-level investments in sewage.

Appendix

Table 7.1

Hookworm Infection Rates In Brazil			
State	No. Examined	No. With Hookworm	% Infected
Maranhão	5320	5139	96.5
Pernambuco	9344	8732	93.4
Alagoas	7065	6677	94.5
Bahia	10604	9633	90.8
Espírito Santo	2066	1801	87.1
Rio de Janeiro	7881	6609	83.9
Minas Gerais	8499	6147	72.3
São Paulo	8751	5150	58.9
Paraná	5169	1651	31.9
Santa Catarina	10577	8582	81.1
Rio Grande do Sul	4220	1670	39.6
TOTAL	79496	61791	77.7
Source: IHB, "Brazil Hookworm Report, 1921." RG 5 3_305 B112 F1440; 28.			

Table 7.2

Hookworm Infection Rates Worldwide: Rockefeller Foundation Surveys					
	% Infected				
Country/Region	**Rural**	**Town**	**Total**	**Year**	**RAC Ref.**
Guatemala	65	61	61	1915	RG 5 3_319, B140, F165
Jamaica	77	38	64	1918	RG 5 3_437, B180, F2245
India	81		61	1917	RG 5, 3_464, B204, F2499
Papau	87	63	61	1917	RG 5 3_472, B210, F2589
China	80	10		1916	RG 5 3_601, B218, F2725
Java, Indonesia			93	1916	RG 3 3_655, B227, F2824
US South			45	1913	RF 5 3_200, B5 F43
Colombia	96	76	88	1921	RG 5 3_311, B133, F1563
Dutch Guiana (Suriname)			84	1915	RG 5 3_659, B229, F2837
Egypt	51	25	51	1915	RG 5 3_485, B213, F2627
Mauritius			41	1922	RG 5 3_478, B212, F2614
Barbados	63	26	58	1916	RG 5 3_305, B179, F2237
Seychelles			85	1924	RG 5 2_477, B51, F322
Panama	97	55		1920	RG 5 2_327, B35, F210
Malaysia	80	59	73	1925	RG 5 2_473, B50, F316
Australia			22	1918	RG 5 3_410, B161, F1961
Dominican Republic			57	1920	RG 5 3_339, B160, F1946
Siam (Thailand)	85	40	59	1917	RG 5 2_617, B56, F358
Dominica			64	1924	RG 5, 2_455, B45, F281
St. Lucia			38	1915	RG 5, 2_455, B45, F281
Antigua			27	1916	RG 5 3_349, B187, F2318
Note: All rates rounded to the nearest 1 percent.					

Conclusion

Although Brazil's economy grew rapidly from 1940 into the twenty-first century, a substantial disparity in health persists between northern and southern regions of the country. In 2015, a difference of roughly 10 years in life expectancy at birth separates the least developed from the most advanced regions. While data constraints precluded direct study of the historical trajectory of these regional discrepancies in human development, this research brings new evidence to bear on long-term trends in heights —a reliable indicator of health and nutritional status. Using two novel datasets culled from military and passport archives, this dissertation explores the evolution of heights in Brazil in birth cohorts ranging from 1850 to 1950. As we have seen, this was a period marked by deep social, political, and economic change, yet we have had a limited understanding of their impact on human development in the nation.

In Chapter 1, I proposed that the public-health policies associated with the First Republic were more progressive than is commonly accepted, given that many historians have tended to view the period as a continuation of the semi-feudal traditions inherited from the slavocratic Colonial and Imperial systems. The existing historical scholarship remains divided regarding the onset of improvements in living conditions for Brazil's working classes, as well as the genesis of persistent inequalities between the country's northern and southern regions. As we also saw in Chapter 1, conventional health and human-welfare indicators, such as life expectancy and infant mortality, have failed to accurately capture longitudinal trends in health and human development at the national level, and their explanatory power in sub-national levels is null. Given the gaps in our knowledge, anthropometric indicators such as heights offer a reliable body of evidence to study human development in nineteenth- and twentieth-century-Brazil since they capture the interaction between nutrition and disease.

In Chapter 3, I discussed the history of military recruitment in the Brazilian army and presented the contours of the large, geographically comprehensive dataset compiled from military inscription files at the AHEX, indicating that the sample squares relatively well with the characteristics of the underlying population it seeks to represent. My findings in Chapter 4 revealed a large upswing in stature following public-health efforts of the early-twentieth century, although a wide gap in heights remained between regions. OLS and truncated ML regressions indicate that stature rose by over 3 cm between 1880 and 1910. This rate of growth in height is commensurate with that observed in more industrialized economies over the mid- to late-twentieth century. While heights improved first in the booming southern regions, heights in the northern regions remained stagnant until the 1910 birth cohort.

Diagnostic tests designed to identify sample-selection biases in historical heights samples indicate that economic conditions prevailing in the year of recruitment did not substantially alter the type of soldier enlisting in the Brazilian army. The results from these tests substantiate the chronological comparisons displayed in the regression results. Further, robustness checks considering alternative hypotheses corroborate the upward trend in the 1880-1910 period. 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, in an effort to exclude the sons of non-Iberian immigrants to Brazil, the cohort estimates reveal a four-centimeter 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.

In Chapter 5, I discussed the ancillary dataset of passport bearers, which is more representative of the upper and middle socio-economic groups. Also, I presented direct evidence on foreign-born, nationalized Brazilians born in the late-nineteenth and early-twentieth century--further evidence to suggest that the influx of migrants was not an important factor in the growth in heights of the Brazilian born. In Chapter 6, we saw that the three-centimeter increase in heights over the 1880-1910 interval in Brazil was large by international standards. Given evidence on the decline in infectious-disease and infant mortality, I argue that early-twentieth-century sanitary reforms increased heights and aided in overcoming the hurdles to development imposed by tropical diseases such as hookworm and malaria.

In Chapter 6, I relied on regression results merging the county-level heights series with a host of environmental variables in order to proxy for the virulence of the disease environment. The dependent variable in these regressions is height from the subset of military records that listed the soldiers' municipalities of birth, and the independent variables of interest are taken from the CRU historical climate dataset. Additional geographic variables, namely the average altitude within each municipal boundary and the corresponding average ruggedness of the terrain, were extracted using GIS. I use the intensity of summer rainfall as a proxy for the risk of contracting enteric pathogens, controlling for several other features such as average temperature, ruggedness, and year-of-birth fixed effects. I divide the military series in two decadal cohorts before and after the first major interventions in rural sanitation in the late 1910s. The results indicate a statistically-significant and negative effect of rainfall intensity on heights; however, the effect of rainfall intensity disappeared in the latter birth cohorts. Further, the variance in heights explained by these environmental variables decreases substantially in the 1920 and 1930 cohorts of birth, suggesting that epidemiological constraints to human growth became less severe.

In Chapter 7, we saw that the burden of hookworm disease in Brazil was one of the highest faced by any other nation surveyed by the Rockefeller Foundation in the early-twentieth-century. Rural health campaigns conducted by the IHB and the Brazilian Rural Prophylactic Service represented a watershed moment in the country's timeline, and I argue that anti-hookworm campaigns explained the rapid increase in stature in 1910s for soldiers born in the Northeast, where hookworm infection was nearly universal prior to the public-health interventions. Despite the success of these early-twentieth-century reforms, persistent poverty, economic volatility, and political crises curtailed the rollout of modern health institutions and hampered human development. Heights continued to incline throughout the twentieth century, but one can argue that Brazil fell short of its growth capacity, since the rate of growth was slower than that observed over the 1880-1910 interval--the period during which stature increased at its highest rate in the country's history.

I conclude that the innovations in sanitation and public health services that emerged out of the early-twentieth-century hygiene movement lessened the burden imposed by infectious diseases and sparked Brazil's epidemiological transition. In Rio de Janeiro, official mortality statistics illustrate a pronounced decline in infant mortality and per capita mortality from diseases such as malaria in the period of observed height increase. Even after the public-health reforms of the early-twentieth century, soldiers from the North and Northeast of Brazil remained shorter than their southern counterparts.

We have known little about why human-development trends in the North and Northeast have remained inferior. One potential explanation for the stagnation is that states in the North and Northeast of Brazil lacked the financial resources necessary to modernize their health institutions, and in the 1910s some states from these regions petitioned for federal funding to implement public works (for running water and sewage systems). I present empirical evidence to suggest that the epidemiological environment was to blame for a good portion of the regional height discrepancy. Further, based on evidence to suggest that the epidemiological environment became a less severe hindrance to growth in stature, I argue that the efforts of the First Republican state to improve the health of the nation were met with considerable success, although economic and political volatility limited this upward trend in human development in the 1920s (and beyond).

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