Infant Birth Weight in Brazil

A Cross-Sectional Historical Approach

Cassia Roth

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# 1. Abstract

## 1.1 Background

In 1888, after nearly four centuries, Brazil became the last country in the Western Hemisphere to abolish slavery. In the aftermath, the state did not create programs to incorporate formerly enslaved people and their descendants into economic, civil, or political life. Qualitative historical research has outlined the gendered and racialized health disparities of people of African descent at the turn-of-the-twentieth century. Epidemiologic studies have shown that health disparities continue to mirror patterns from over a century ago. The goal of this study is to quantify health disparities in the post-abolition period using infant birth weight in one of Brazil’s first public maternity hospitals.

## 1.2 Methods

This cross-sectional analysis used hospital records on infants delivered between 1922-1926 at the Maternidade Laranjeiras (now Maternidade Escola) in Rio de Janeiro, Brazil, the city’s first public maternity hospital. It used linear models to assess differences in infant birth weight by maternal skin color, age, number of pregnancies (parity), and nationality.

## 1.3 Findings

African ancestry was correlated with lower birth weights. Infants born to Afro-descendant women had birth weights estimated to be 85 grams lighter (p-value = 0.002 [95% CI -138, -32]) than infants born to Euro-descendant women, whether Brazilian or immigrant. Among Afro-descendant women, infants born to Black (*preta*) women had birth weights estimated to be 100 grams lighter (p-value = 0.001 [95% CI -160, -39]) than infants born to White women, and infants born to mixed-race (*parda*) women had birth weights estimated to be 72 grams lighter (p-value = 0.019 [95% CI -131, -12]) than infants born to White women.

## 1.4 Interpretations

The findings were likely the consequence of the historical legacies of slavery, particularly race-based socioeconomic inequality – including more strenuous work schedules, poorer nutrition, and less sanitary living environments for women of African descent – and possible epigenetic effects from the lived experience of racism. The findings are consistent with current-day research on racialized health disparities in Brazil, demonstrating the need to address the root causes of racism and its effects on health.

## 1.5 Funding

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# 2. Introduction

This study analyzes infant birth weight as a proxy for general maternal and fetal health in relation to maternal skin color (Black, mixed-race, White), controlling for maternal age, parity (nulliparous, multiparous), and nationality (European, Latin American, Middle Eastern, Brazilian) in the Maternidade Laranjeiras, a public maternity hospital in Rio de Janeiro, Brazil between 1922 and 1926. It aims to provide basic quantitative associations of the health status of the descendants of enslaved individuals in post-abolition Brazil, substantiating the qualitative findings from other researchers on health disparities stemming from slave societies, disparities that existed but did not wholly determine patients’ lives.

Birth weight and its relationship to infant health have been a focus of public health research for over a century (1). In epidemiology, both low birth weight (LBW) and preterm birth (PTB), or infants born <37 weeks’ gestation, within and across racialized communities have garnered attention (1–5). LBW can be a function of PTB, of fetal growth restriction (FGR, previously known as intra-uterine growth restriction or IUGR, which can include but is not limited to small-for-gestational-age or SGA infants – those born at less than the 10th percentile), or of both (5,6). Nonetheless, PTB is an important determinant of both LBW and lower birth weight in general (7).

Multiple social, economic, biological, and genetic factors influence birth weight, which is also partially conditioned by maternal nutrition, health, and health care utilization during pregnancy (2,3,8). Recent genetic studies have detailed the specific alleles through which both the maternal and fetal genomes contribute to birth weight and gestational length, while acknowledging the continued importance of non-genetic factors (9–11). Given that these studies are based on well-off populations in countries with low neonatal and infant mortality rates, they might overestimate genetic impact on birth weight for historical studies of impoverished populations.

Although not a causal mechanism, LBW is associated with higher rates of neonatal and infant mortality (12,13). Originally, epidemiologists hypothesized an association between at-term LBW and increased risk for cardiovascular diseases and other chronic physical health conditions over the life course (14). Yet, more recent genetic research and epidemiological studies employing instrumental variable (IV) analysis contest long-term trends associated with “fetal programming” (7,11).

Historians, using hospital records, have shown how birth weight can be an indicator for the often unmeasurable nutritional status of mothers of different social classes in the past (8,15–18). Historically, women from more privileged groups had heavier infants than women from less advantaged groups (8,19).

The differences between and within groups both today and in the past have given rise to much research stratified by racial classification. Public health and medical research over the past twenty years has shown that while race is a social construct and thus biological fiction, its social consequences – namely racism and its potential effects – have far-reaching influences on health and disease patterns, particularly in countries with high levels of race-based inequality (20,21). Thus, racism and racist policies also can influence birth outcomes. Contemporary studies in Brazil have shown that non-White mothers have higher odds of giving birth to LBW infants (13,22,23). Non-White mothers also had infants with lower mean birth weights than their White counterparts (24). These trends also hold true in the United States, the other major slave society in the Americas, where today Black newborns are at higher risk for LBW than White newborns, with trends worsening over time (25). Racism is a possible upstream contributor, as studies demonstrate that U.S.-born Black women have higher risk for both LBW and PTB than Black immigrant women (2,3).

Scholars across disciplines have argued that racialized health disparities in countries with histories of race-based chattel slavery are longstanding and tied to the unequal and violent social relations produced under that institution (18,26–28). Studies in the human sciences have hypothesized an intergenerational effect of poor health conditions, including undernutrition and excessive workloads, experienced by enslaved individuals on their descendants across multiple generations (26,28,29). In Brazil, most historical studies of health under slavery and its aftermath remain descriptive and have not tested quantitative associations between the institution’s legacies, including both race-based socioeconomic inequality and the deleterious effects of racism, and maternal-infant health outcomes (30–33).

Brazil imported over five million enslaved Africans during the nearly four centuries of the existence of chattel slavery (34). It was also the last country to abolish slavery (1888) in the Western Hemisphere. In the nineteenth century, population-level health was poor for all Brazilians, but especially for enslaved individuals, who experienced epidemic and endemic diseases such as cholera, tuberculosis, and yellow fever as well as undernutrition and violent corporal punishment (35). Excluding pregnant and nursing women, historians have argued that caloric intake for the enslaved population was probably sufficient in terms of quantity, yet it lacked key nutrients, and thus the enslaved suffered from nutritional deficiencies, including insufficient thiamine, which was associated with infant mortality (35,36). Today, thiamine deficiency is correlated with lower birth weight and adverse perinatal outcomes including neonatal death (37,38).

In the aftermath of abolition, no state-run efforts to incorporate formerly enslaved, African-descended peoples into economic, civic, or political life occurred (39). Scholars have shown how Black and mixed-race Brazilians were incarcerated at higher rates, had lower literacy levels, and had worse health outcomes than their White and White immigrant counterparts (30,31,39,40).

Yet recent studies also show an overall improvement in human welfare for those who survived infancy during this period, measured in increased height at the population level, particularly in Brazil’s southeastern region, where Rio de Janeiro is located (41). The early twentieth century was a period of advancement in both the provision of clinical care and the implementation of public health initiatives in Brazil and across the globe. Improved sanitation measures helped stem infectious disease outbreaks (42,43). Infant mortality rates declined from the nineteenth century, although the major advancements in clinical medicine that provided a sustained improvement in maternal mortality, stillbirth, and infant mortality rates, including blood transfusions and antibiotics, did not come about until the late 1930s and early 1940s (30,32,44,45).

Maternidade Laranjeiras, which opened in 1904 and was the teaching hospital for the obstetrics and gynecology program at Rio de Janeiro’s medical school, provided healthcare free of charge; its clientele came from the city’s poor and working classes (32,46). Most patients were women of color defined as either Black or mixed race, and most White patients were immigrants, the majority from Europe.

In exploring differences in infant birth weight according to maternal skin color in early twentieth-century Brazil, my aim is not to reify race as a genetic or epigenetic phenomenon. In our current postgenomic era, race as a biological category has been rejected, yet the possibility for the reaffirmation of centuries-old patterns of hierarchical scientific thinking in epigenetics remains very real (20). Although differences between racialized groups existed, they were not immutable or due to genetic differences based on race. The working-class women and their children who relied on Laranjeiras for prenatal and delivery care were not part of permanently “damaged” communities (socially or biologically) but rather were living the consequences of centuries of chattel slavery and its aftermath (47).

# 3. Methods

## 3.1 Data

This analysis draws on a unique dataset of 2,845 recorded clinical visits, most of them deliveries, to Maternidade Laranjeiras between 1922 and 1926. I extracted the sample from Brazil’s premier obstetrics and gynecology journal, the *Revista de Gynecologia e d’Obstetricia* (RGO), which, between June 1922 and May 1926, published the monthly clinical reports of all women treated at Laranjeiras. I was unable to locate vol. 18, nos. 4, 5, 6, 8 (1924) and vol. 20, no. 4 (1926).

I recorded the following information, when available, for all patients: patient number, parity, skin color, age, nationality, type of delivery (natural, interventionist, operative), maternal outcome (death, discharge, transferal to separate hospital), birth outcome (spontaneous abortion, stillbirth, live birth, or neonatal death), and the mother’s reproductive history.

The journal is held at the Biblioteca Nacional (BN), the Maternidade Escola, Rio de Janeiro (ME-UFRJ), and the Biblioteca CB/A-Biomédica A, Universidade Estadual do Rio de Janeiro (UERJ), all in Rio de Janeiro, Brazil. Between January 2012 and July 2013, I manually digitized the journal by photographing each volume. Then, between January and August 2017, I manually input the data into Excel from the digital reproductions. I then converted this into a .csv file for upload into R version 4.4.1 (2024-06-14).

The project’s Github repository, particularly the Supplemental\_Materials file, includes summary information on data processing, exploratory analysis, and model fitting. All materials, including the data set, are open access and reproducible, with instructions on the schematic of the workflow available online.

## 3.2 Variables

### 3.2.1 Outcome

*Birth weight*. The outcome was birth weight measured as a continuous variable in grams for live births only, in line with both current and historical studies (3,15,16,24,48,49). In a secondary analysis (see Supplement, I also evaluated birth weight as a binary variable (either normal birth weight, NBW g or low birth weight, LBW g), according to current WHO classifications) (50).

### 3.2.2 Key Independent Variables

*Maternal skin color*. The original records categorized maternal skin color as White (*branca*), the reference group; mixed-race (*parda*); and Black (*preta*). I maintained this categorization. However, I also created a new dummy variable for skin color, combining Black and mixed-race patients into one category, Afro-Descent, and White patients into a Euro-Descent category.

Except at the extremes, racial classification in Brazil was, and continues to be, imprecise, as racial categories and skin color exist on a spectrum rather than as a Black-White binary (21). Using more general categories addresses imprecision by grouping all possible mothers of any African descent into one category. This method also is in line with recent studies, which look at all African-descended peoples as a group and then stratify by racial mixing (22,23).

*Maternal age*. I maintained the original data of maternal age in years.

*Gestational status*. The original hospital records divided gestational status into eight categories of parity and gravidity: nulliparous, primiparous, secundiparous, and multiparous; and primigravida, secundigravida, trigravida, and multigravida. Due to issues of statistical power, I combined these into two categories: 1) nulliparous, which included nulliparous, primigravida, and primiparous (any woman giving birth for the first time); and 2) multiparous, which included secundiparous, multiparous, secundigravida, trigravida, and multigravida (any woman who has given birth more than once).

*Maternal nationality*. The original hospital records recorded maternal nationality by country. For analysis, I created categories based on individual country (Nationality) and a dummy variable based on region (ModifiedNationality). I recategorized the latter as follows: Brazilian; Latin American (Argentine, Paraguayan, Uruguayan); European (Austrian, French, German, Italian, Polish, Portuguese, Romanian, Russian, Spanish, and Swiss); and Middle Eastern (Syrian). For a sub-sample analysis to test collinearity between nationality and skin color, I further created a dummy category between Brazilian and Non-Brazilian.

### 3.2.3 Key Descriptive Variables

*Birth*. I followed the original clinical categorizations for type of delivery in the following cases: natural, indicating minimal medical intervention and a vaginal delivery; interventionist, indicating medium medical intervention using forceps and a vaginal delivery; and operatory, indicating a cesarean section or embryotomy. However, I recategorized external manipulations including version and Mauriceau (used during breech deliveries), coded as operatory or natural by hospital records, as interventionist. I classified spontaneous abortion as a separate category.

*Infant length*. Infant length was recorded in centimeters in the original records.

*Maternal outcome*. Hospital records recorded maternal outcome as death, discharge, or hospital transferal, which I maintained. I assume that hospital transferal did not result in maternal death in my calculations of maternal mortality below.

*Fetal outcome*. I recorded fetal outcome as live birth or stillbirth. For the statistical models, I excluded both spontaneous abortions (recorded in the birth variable) and any recorded live births weighing <500 grams to avoid the inclusion of any possible stillbirths that were misrecorded as live births in the original data, which is standard methodology for looking at infant birth weight today (22,23,51). The hospital records recorded 20 neonatal deaths, which I included in the live birth category. These numbers could be higher, as the hospital only recorded deaths within the first week of life, when the infant was still hospitalized.

*Fetal sex*. I maintained the original hospital categories of fetal sex as male and female.

## 3.3 Descriptive statistics

I calculated sample proportions for maternal skin color, maternal ancestry, parity, maternal nationality, birth outcome, maternal outcome, fetal outcome, and fetal sex. I also calculated mean maternal age, infant birth length, and infant birth weight, unadjusted and then stratified by first fetal sex and then maternal skin color.

Finally, I calculated the maternal mortality ratio (MMR) and the mean stillbirth rate (SBR). In the Supplement, I calculated the sex ratio at birth (SRaB).

The (MMR) is:

where maternal deaths (MD) are divided by 10,000 live births (LB). In current studies, MD are divided by 100,000 LB, but I use 10,000 in the denominator, which is in line with historical studies given the higher rates of deaths in the past and reporting uncertainties (44).

The SBR (excluding spontaneous abortion but including intrapartum death defined here as stillbirth) for the hospital, is:

where the total number of stillbirths (SB) is divided by 1000 total births (TB).

## 3.4 Statistical analysis

I used Ordinary Least Squares (OLS) to establish a relationship of maternal variables and infant birth weight. Due to the lack of comprehensive information on gestational age, I did not consider birth weight in reference to gestational age. I discuss this constraint in the discussion below.

I ran four linear models: two in which I categorized maternal skin color into two ancestral groups: White (Euro-descent), the reference group, and non-White (Afro-descent), and two in which I categorized maternal skin color according to the hospital records’ original racial classifications: White (the reference group), Black, and mixed race to see if there were differential outcomes for Black and mixed-race women. The independent variables include maternal age, maternal skin color, gestational status, and maternal nationality.

The simple linear regression model for modified ancestry is:

whereas BW is birth weight in grams, is the average birth weight, is the group deviation from the average birth weight, MA is maternal ancestry (Euro-descent, Afro-descent), and is the error term.

The multiple linear regression model for modified ancestry is:

whereas BW is birth weight in grams, is the average birth weight, are the group deviations from the average birth weight, MA is maternal ancestry (Euro-descent, Afro-descent), Gest is gestational status (nulliparous or multiparous), Age is maternal age in years, and is the error term. Results for both models are displayed in Table 2.

The simple linear regression model for original skin color is:

whereas BW is birth weight in grams, is the average birth weight, is the group deviation from the average birth weight, MC is maternal skin color (White, Black, and mixed race), and is the error term.

The multiple linear regression model for original color is:

whereas BW is birth weight in grams, is the average birth weight, are the group deviations from the average birth weight, MC is maternal skin color (White, Black, and mixed race), Gest is gestational status (nulliparous or multiparous), Nat is maternal nationality (Brazilian, Latin American, European, Middle Eastern), Age is maternal age in years, and is the error term. Results for both models are displayed in Table 3.

Scholars have shown that immigrants to Brazil during this historical period were healthier and better off socio-economically than their Brazilian counterparts of all skin colors (40,41). Given the possibility for collinearity between maternal nationality and maternal skin color, I ran a sub-sample analysis for Models 1 and 2 (modified ancestry) in two steps. First, I created a new dichotomous variable, Brazilian/Non-Brazilian and ran a simple linear analysis with birth weight as the outcome and maternal nationality as the independent variable. Non-Brazilian women birthed infants that weighed on average 100 g more than Brazilian women (the reference group) (p-value = 0.001 [95% CI 40, 161]). Given that all women of color in the data set were Brazilian, collinearity exists. Second, I dropped all non-Brazilians and ran the original simple and multiple regressions from Models 1 and 2. Results for the sub-sample analysis are included in Table 2.

# 4. Results

Table 1 provides summary statistics for the dataset. In the hospital records, 58% were of African descent (defined as *preta* or *parda*) and 42% were of European descent (*branca*). First-time mothers (nulliparous) comprised 41%. Of all women, 84% were Brazilian. Of the nearly 16% immigrant patients, 15% were from Europe.

Of all reproductive outcomes, excluding spontaneous abortion, 91% were natural deliveries. The remaining 9% were interventionist or operative deliveries. For patients who went to the clinic to deliver their infant (excluding spontaneous abortion), 23 died, for an MMR of 94.1%. The SBR was 82.9%.

The overall rate of LBW for infants born to Afro-descended mothers was 12.4%, compared to 9.7% for Euro-descended mothers. A difference in means test showed borderline significance at the alpha 0.05 level (t-statistic = 1.9119, df. 2008.2, p-value = 0.056, [95% CI -0.0007, 0.0532]).

Results for all linear models are displayed in Tables 2 and 3. All models demonstrated an association between maternal skin color and infant birth weight, with Euro-descended women (either as Euro-descended or as White, the reference groups) having infants with higher birth weights than Afro-descended women (either as Afro-descended, Black, or mixed race). When recategorizing maternal skin color into two categories (Afro- and Euro-descended) and running the full model, Afro-descended women had infants who weighed on average 85 grams lighter (p-value = 0.002 [95% CI -138, -32]) than their Euro-descended counterparts (Table 2). In Table 3, which shows the models run using the hospital records’ original skin color categories, Black mothers gave birth to infants weighing on average 100 grams lighter (p-value = 0.001 [95% CI -160, -39]) than White mothers, while mixed-race mothers gave birth to infants weighing on average 72 grams lighter (p-value = 0.019 [95% CI -131, -12]) than White mothers. Infants born to women of African descent were both lighter and more likely to be LBW than infants born to women of European descent.

Research has shown that below 3000 g, risk of death in the first week of life increases by 40% for every 100 g decrease in birth weight (19,52). More recent studies relying on IV have found that a 10% increase in any birth weight decreases infant mortality by 13.3 deaths per 1000 live births (7). Applied to these data, an 85 g difference in birth weight between Afro- and Euro-descended infants (sub-model 2) would have increased infant mortality among Afro-descended children by 3.7 deaths per 1000 births.

In all models (Tables 2 and 3), women who were nulliparous (delivering their first child) had lighter infants weighing than multiparous women, an association recognized by physicians at the time and found in both other historical studies and today (15,53,54). Age and nationality were not significant.

# 5. Discussion

In general, maternal and infant outcomes were not better in the Maternidade Laranjeiras than among the wider population. Between 1922 and 1926, the clinic’s MMR was 94.26%. For those same years, the MMR for the city of Rio de Janeiro was 65.65% (32). Hospital rates probably reflected a registration effect, as medical personnel recorded all births and deaths, whereas reporting at the city level was less reliable (44). Rio de Janeiro’s vital statistics were still poorly defined and intermittently collected in the 1920s (32). Thus, the city’s rates were probably higher. The same pattern holds for the SBR, which was 84.8% for Laranjeiras and 73.68% for the city of Rio de Janeiro for the same period (32). However, these differences demonstrate that delivering in the presence of licensed clinicians did not necessarily improve outcomes for the mother and infant and supports other historical studies that interventionist obstetric procedures before antibiotics and blood transfusions could be detrimental to maternal-infant health (17).

This study found that women of African descent in early twentieth-century Brazil both had infants with lower birth weights and higher rates of LBW than their White counterparts, perhaps indicative of higher rates of PTB. Wilcox (5) has questioned the utility of the LBW category in epidemiological studies given its arbitrary nature. We can question the use of this cutoff in historical studies as well, as it was not an established category until the mid-twentieth century. A Finnish pediatrician first proposed the 2500 g cutoff in 1919 without any specific justification (1). This was a period in which it was difficult for physicians to accurately calculate gestational age, and thus many physicians used birth weight as a proxy for prematurity. The WHO adopted this cutoff in 1948, and it has remained the standard ever since even as epidemiologists began to differentiate between small-for-gestational age (SGA, now FGR) and PTB in the 1970s (1,5). Physicians in early twentieth-century Rio de Janeiro defined low birth weight as and normal birth weight as between 3000 and 3500 g (53).

Regardless of its arbitrariness, LBW was dangerous in the past given that the probability of surviving the neonatal period was lower than today due to higher neonatal and infant mortality rates and less effective medical interventions (7,15,32).

Table 4 provides the mean birth weights for the Laranjeiras sample, stratified by sex and maternal skin color in comparison with both current-day birth weights from various regions in Brazil and historical studies on birth weight globally. Black infants born at Laranjeiras had the lowest mean birth weight (3037 g) when analyzed in conjunction with other historical samples except for estimated enslaved birth weights in the antebellum US South (18), which scholars have since called into question for being too low (16). Black infants born at Laranjeiras were almost 150 g lighter than Black infants born at the Johns Hopkins hospital during an equivalent historical period. They were less than 100 g lighter than Black infants born to mothers with incomplete K-12 schooling in early twenty-first-century Rio de Janeiro. White infants born at Laranjeiras had a mean birth weight of 3133 g, nearly 300 g lighter than White infants born at the Johns Hopkins hospital during an equivalent historical period (3423 g). They were slightly more than 50 g lighter than White infants born to mothers with incomplete K-12 schooling in early twenty-first-century Rio de Janeiro. Differences between racialized groups existed both historically and continue to exist today. Moreover, when compared both historically and contemporaneously, we can see that women of all colors at Laranjeiras did not fair as well as their counterparts in other major cities.

As scholars have shown, mean birth weights in the past were not drastically lower than today, and Laranjeiras fits this pattern, with birth weights relatively close to those of contemporary Brazilian infants even if lower than infants born in other regions during the same historical period (15–17). Across populations, relatively high mean birth weights in the nineteenth and early twentieth centuries are probably an artifact of high stillbirth and neonatality rates (15,16). Today, PTB and lower birth weight infants that probably would have died in utero 100 years ago are now surviving, bringing the mean birth weight down.

What can explain the differences in birth weight historically both between women at Laranjeiras and those of other historical populations and among different skin-color groups within Laranjeiras? Although both maternal and fetal genetic factors (9–11) and maternal age, parity, birth spacing, and gestational age all condition birth weight (19), the intrauterine environment remains a critical determinant. In this study, maternal age was not a significant factor, although multiparous mothers had infants with higher birth weights, as is common today. The data did not provide information on birth spacing or gestational age, the latter which I discuss below in the limitations.

What about external factors related to poverty? Infectious disease, alcohol or drug use, smoking, heavy physical work, and inadequate prenatal care also influence birth weight (19). Maternal nutrition can as well, although the relationship is nonlinear in that the pregnant body protects the fetus at the expense of the mother, and a threshold of malnutrition must be met before there is an adverse effect on fetal growth (15,18,19). Yet nutritional deficiencies that were found among African-descended populations in nineteenth-century Rio de Janeiro due to slavery were associated with lower birth weights and infant mortality (35–38). Although working women of all skin colors in the early twentieth century had more control over their diets than did the enslaved, food was expensive and many of the nineteenth-century trends in nutritional deficiencies continued in the early twentieth century (30).

We also know that poorer women in early twentieth-century Rio de Janeiro performed physically taxing jobs that required them to stand for long periods of time, including as washerwomen, domestic help, and street vendors (55). And working-class women of all skin colors often worked through the third trimester as domestic servants (32). These same women might have lived in crowded housing arrangements with lack of access to running water (32,39,55). Thus, generalized poverty might have influenced women of African descent’s nutrition, physical routines, and ability to access prenatal care.

Because the hospital records excluded information on maternal health factors, we don’t know which contributed to racial disparities in infant birth weight. One possible cause that we do have some data for is syphilis. Like Costa found for early twentieth-century Baltimore, higher syphilis rates among African-descended women in Rio de Janeiro might have explained lower birth weights. Studies demonstrate that syphilis increases adverse birth outcomes including increased risk of LBW and PTB (56). The clinical records that comprise this dataset did not consistently record syphilis rates, although sporadic notes showed it existed. Medical and public health professionals of the time viewed it as an important cause of adverse health outcomes (57). City-wide rates from the 1930s can provide some context for the prevalence of infection among pregnant women. Of all prenatal syphilis exams performed between 1935 and 1938 at public clinics or hospitals across the city, unadjusted for maternal skin color, 7.92% came back positive (58).

Discussions of epigenetic markers associated with the lived experience of racism might also be applicable. Studies have connected racial disparities in pregnancy outcomes, including PTB and LBW, with the accumulation of stress over the pregnant person’s life course (and the life courses of their ancestors) understood as allostatic load measured by biomarkers such as cortisol and blood pressure, mediated through epigenetic mechanisms (29). Although there is no genetic basis for race, experiences of racism can result in the accumulation of stressors that can be expressed epigenetically and lead to adverse pregnancy and health outcomes across generations through transgenerational epigenetic inheritance (26,29). Yet, it is crucial to remember that these are not deterministic processes but can be counteracted by social and political interventions that address the root causes of racism and its effects on health (20).

*Strengths and Limitations*

This study contributes heretofore unpublished hospital records from one of Brazil’s most important public maternity hospitals in the early twentieth century, a hospital that remains in operation today. It provides quantitative evidence of racialized disparities in maternal-infant health in early twentieth-century Brazil. These findings are thus useful to compare to present-day research to assess the extent of progress in improved outcomes over time. They also complement descriptive historical studies and provide a base for qualitative research to analyze individual experience in the past.

All models based on historical data must contend with limited sample sizes, missing data, and imprecise measures of health and nutrition (8,41,59,60). Physicians could have introduced systematic measurement error when weighing newborns in Laranjeiras, either through inconsistent practices or inaccurate equipment. The hospital records do not provide information on weighing practices, but published observations from medical students who trained at Laranjeiras show that the norm was to weigh all newborns without clothes on a calibrated scale (53). Thus, an upward bias to the mean through the inclusion of clothing or blankets for all infants seems unlikely. It also seems unlikely that physicians weighed infants of one skin color in a different method than those of another given that Laranjeiras was the premier teaching hospital associated with a major medical school. If any upward bias existed, weights were even lower than presented here.

Additionally, physicians could have introduced rounding error as all birth weights at Laranjeiras were rounded to the nearest 50 g. Yet, the theoretical upper bound on bias is 50 g, and my results show a difference greater than 50 g. Goldin (17) has shown for Philadelphia that heaping did not systematically bias the mean, and I assume the same here.

In this study, a major limitation was the original published clinical notes’ exclusion of gestational age. Thus, the birth weight variable captured both smaller babies born at term, whether with or without FGR, and PTB. (61). This limits our ability to understand the relationship between maternal variables and infant birth weight as pre-term infants are more likely to have lower birth weights (5,6,61). Given the absence of accurate technological techniques for determining gestational age in the past, this limitation is inherent to many historical inquiries into birth weights. Yet, the factors discussed here could have contributed PTB, to FGR, or to both.

A more complete analysis would further explore interactions between birth weight and birth length, which can be a proxy for the nutritional and health status of the mother later in pregnancy (62). The third trimester is when most fetal weight gain occurs, and maternal malnutrition during this period can have a dramatic effect on infant birth weight (8,26).

Today, lower mean birth weights between populations are not necessarily associated with worse health outcomes (5). Yet continued differences between racialized groups hints at the possible role of socio-economic inequity and racism in determining health outcomes. In addition, studies relying on IV analysis have shown that even in the recent past in developed countries, the impact of birth weight on adverse perinatal and neonatal outcomes has declined over the past 35 years given advances in medical care (7). We can imagine that 100 years ago, the association of birth weight, most likely as a proxy for PTB, with adverse neonatal outcomes was even greater. Finally, birth weights studied historically are as important for understanding their mother’s past lives as for predicting perinatal or neonatal outcomes (8).

Lack of data on maternal nutrition and health status or maternal work routine and income, all of which cannot be corrected for by using maternal skin color as a proxy, is a major impediment to understanding the true relationship between maternal variables and infant birth weight in this study. Maternal skin color may serve as a partial index of the unobservable variables that acted upon infant birth weight (8,16). Given the paucity of historical understandings of current-day health disparities in maternal-infant health, this paper demonstrates the need for more research into quantitative associations between socio-demographic categories and health in the past.

*Conclusion*

This study has shown that lower birth weights were associated with Afro-descended women giving birth in the Maternidade Laranjeiras in Rio de Janeiro, Brazil between 1922 and 1926. This suggests that racial inequality stemming from slavery impacted health conditions in the post-abolition period, possibly through multiple mechanisms for which we do not have direct evidence. These findings, although not generalizable beyond this specific hospital, are consistent with present-day studies on racialized disparities in birth weight in Rio de Janeiro, demonstrating how racial inequality in health outcomes has persisted over time.

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| Table 1: Summary Statistics   | **Characteristic** | **N** | **N = 2,845**1 | | --- | --- | --- | | Color | 2,695 |  | | Black |  | 763 (28%) | | Mixed Race |  | 788 (29%) | | White |  | 1,144 (42%) | | Ancestry | 2,695 |  | | Afro-Descent |  | 1,551 (58%) | | Euro-Descent |  | 1,144 (42%) | | Parity | 2,836 |  | | Multiparous |  | 1,681 (59%) | | Nulliparous |  | 1,155 (41%) | | Maternal Age | 2,783 | 25.3 (21.0, 29.0) | | Combined Nationality | 2,773 |  | | European |  | 416 (15%) | | Latin American |  | 12 (0.4%) | | Brazilian |  | 2,342 (84%) | | Middle Eastern |  | 3 (0.1%) | | Birth Outcome | 2,761 |  | | Abortion |  | 89 (3.2%) | | Interventionist |  | 183 (6.6%) | | Natural |  | 2,429 (88%) | | Operative |  | 60 (2.2%) | | Maternal Outcome | 2,829 |  | | Discharged |  | 2,802 (99%) | | Death |  | 23 (0.8%) | | Hospital transferal |  | 4 (0.1%) | | Fetal Outcome | 2,666 |  | | Live Birth |  | 2,445 (92%) | | Stillbirth |  | 221 (8.3%) | | Sex | 2,534 |  | | F |  | 1,153 (46%) | | M |  | 1,381 (54%) | | Birth Length (cm) | 2,405 | 48.3 (47.0, 50.0) | | Birth Weight (g) | 2,384 | 3,087 (2,800, 3,450) | | Black | 643 | 3,037 (2,750, 3,250) | | Mixed-Race | 675 | 3,064 (2,750, 3,450) | | White | 950 | 3,133 (2,850, 3,500) | | Afro-Descent | 1,318 | 3,051 (2,750, 3,350) | | Euro-Descent | 950 | 3,133 (2,850, 3,500) | | Female | 1,074 | 3,038 (2,750, 3,350) | | Male | 1,270 | 3,137 (2,800, 3,500) | | Birth Weight Category | 2,234 |  | | LBW |  | 255 (11%) | | NBW |  | 1,979 (89%) | | 1n (%); Mean (IQR) | | | |

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| Table 2: Model 1 and 2 Results (Dependent variable: Birth weight in grams)   |  | **Model 1** | | | **Sub-Model 1** | | | **Model 2** | | | **Sub-Model 2** | | | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **Characteristic** | **Beta**1 | **SE**2 | **T-Statistic** | **Beta**1 | **SE**2 | **T-Statistic** | **Beta**1 | **SE**2 | **T-Statistic** | **Beta**1 | **SE**2 | **T-Statistic** | | (Intercept) | 3,188\*\*\* | 17.7 | 180 | 3,171\*\*\* | 22.2 | 143 | 3,152\*\*\* | 65.5 | 48.1 | 3,148\*\*\* | 70.9 | 44.4 | | Age |  |  |  |  |  |  | 2.7 | 2.23 | 1.22 | 2.7 | 2.45 | 1.11 | | ModifiedColor |  |  |  |  |  |  |  |  |  |  |  |  | | Euro-Descent | — | — | — | — | — | — | — | — | — | — | — | — | | Afro-Descent | -99\*\*\* | 23.0 | -4.31 | -83\*\* | 26.5 | -3.13 | -85\*\* | 26.9 | -3.17 | -85\*\* | 26.4 | -3.22 | | ModifiedNationality |  |  |  |  |  |  |  |  |  |  |  |  | | Brazilian |  |  |  |  |  |  | — | — | — |  |  |  | | European |  |  |  |  |  |  | 27 | 36.6 | 0.727 |  |  |  | | Latin American |  |  |  |  |  |  | 75 | 166 | 0.451 |  |  |  | | Middle Eastern |  |  |  |  |  |  | 526 | 494 | 1.07 |  |  |  | | ModifiedStatus |  |  |  |  |  |  |  |  |  |  |  |  | | Multiparous |  |  |  |  |  |  | — | — | — | — | — | — | | Nulliparous |  |  |  |  |  |  | -113\*\*\* | 25.3 | -4.47 | -104\*\*\* | 27.0 | -3.86 | | No. Obs. | 1,920 |  |  | 1,611 |  |  | 1,920 |  |  | 1,611 |  |  | | R² | 0.010 |  |  | 0.006 |  |  | 0.027 |  |  | 0.021 |  |  | | 1\*p<0.05; \*\*p<0.01; \*\*\*p<0.001 | | | | | | | | | | | | | | 2SE = Standard Error | | | | | | | | | | | | | |

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| Table 3: Model 3 and 4 Results (Dependent variable: Birth weight in grams)   |  | **Model 3** | | | **Model 4** | | | | --- | --- | --- | --- | --- | --- | --- | | **Characteristic** | **Beta**1 | **SE**2 | **T-Statistic** | **Beta**1 | **SE**2 | **T-Statistic** | | (Intercept) | 3,188\*\*\* | 17.7 | 180 | 3,153\*\*\* | 65.5 | 48.1 | | Age |  |  |  | 2.7 | 2.23 | 1.20 | | Color |  |  |  |  |  |  | | White | — | — | — | — | — | — | | Black | -112\*\*\* | 27.6 | -4.05 | -100\*\* | 30.9 | -3.23 | | Mixed Race | -88\*\* | 27.2 | -3.23 | -72\* | 30.5 | -2.35 | | ModifiedNationality |  |  |  |  |  |  | | Brazilian |  |  |  | — | — | — | | European |  |  |  | 27 | 36.6 | 0.728 | | Latin American |  |  |  | 75 | 166 | 0.452 | | Middle Eastern |  |  |  | 526 | 494 | 1.07 | | ModifiedStatus |  |  |  |  |  |  | | Multiparous |  |  |  | — | — | — | | Nulliparous |  |  |  | -114\*\*\* | 25.3 | -4.50 | | No. Obs. | 1,920 |  |  | 1,920 |  |  | | R² | 0.010 |  |  | 0.028 |  |  | | 1\*p<0.05; \*\*p<0.01; \*\*\*p<0.001 | | | | | | | | 2SE = Standard Error | | | | | | | |

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| Table 4: Mean Birth Weights   | **Sample** | **Year** | **Mean (grams)** | **Source** | | --- | --- | --- | --- | | Antebellum US South (estimated enslaved) | <1850 | 2320 | Steckel, 1986 | | Rio de Janeiro (Black singletons) | 1922-26 | 3037 | Laranjeiras | | Rio de Janeiro (female singletons) | 1922-26 | 3038 | Laranjeiras | | Rio de Janeiro (Mixed-race singletons) | 1922-26 | 3064 | Laranjeiras | | Rio de Janeiro (singletons all) | 1922-26 | 3087 | Laranjeiras | | Riberão Preto, São Paulo, Brazil | 1994 | 3115 | Silva, 1998 | | Rio de Janeiro (Black singletons, mothers <K-12) | 1999-2001 | 3122 | Leal, 2006 | | Rio de Janeiro (White singletons) | 1922-26 | 3133 | Laranjeiras | | Rio de Janeiro (male singletons) | 1922-26 | 3137 | Laranjeiras | | Rio de Janeiro (Mixed-race singletons, mothers <K-12) | 1999-2001 | 3154 | Leal, 2006 | | São Paulo, Brazil (live) | 1993-98 | 3155 | Monteiro, 2000 | | Pelotas, Rio Grande do Sul, Brazil (live singletons) | 2004 | 3167 | Silveira, 2019 | | Pelotas, Rio Grande do Sul, Brazil (live singletons) | 1993 | 3169 | Silveira, 2019 | | Baltimore (Black singletons) | 1897-1935 | 3183 | Costa, 2004 | | Rio de Janeiro (Black singletons, mothers >=K-12) | 1999-2001 | 3185 | Leal, 2006 | | Rio de Janeiro (White singletons, mothers <K-12) | 1999-2001 | 3186 | Leal, 2006 | | Pelotas, Rio Grande do Sul, Brazil (live singletons) | 2015 | 3198 | Silveira, 2019 | | Pelotas, Rio Grande do Sul, Brazil (live singletons) | 1982 | 3201 | Silveira, 2019 | | Rio de Janeiro (Mixed-race singletons, mothers >=K-12) | 1999-2001 | 3210 | Leal, 2006 | | Rio de Janeiro (White singletons, mothers >=K-12) | 1999-2001 | 3218 | Leal, 2006 | | Riberão Preto, São Paulo, Brazil | 1978-79 | 3234 | Silva, 1998 | | Boston (in hospital) | 1886-1900 | 3330 | Ward, 1993 | | Philadelphia (all) | 1848-73 | 3375 | Goldin, 1989 | | Philadelphia (live) | 1848-73 | 3403 | Goldin, 1989 | | Wellington, NZ (singleton live female) | 1907-22 | 3403 | Roberts, 2014 | | Baltimore (white singletons) | 1897-1935 | 3423 | Costa, 2004 | | New York (singeltons) | 1910-31 | 3463 | Costa, 1998 | | Wellington, NZ (singleton live) | 1907-22 | 3467 | Roberts, 2014 | | Boston (at home) | 1884-1900 | 3479 | Ward, 1993 | | Boston | 1872-1900 | 3480 | Ward, 1993 | | Wellington, NZ (singleton live male) | 1907-22 | 3531 | Roberts, 2014 | |

1. Hughes MM, Black RE, Katz J. [2500-g Low Birth Weight Cutoff: History and Implications for Future Research and Policy](https://doi.org/10.1007/s10995-016-2131-9). Maternal and Child Health Journal. 2017;21(2):283–9.

2. Braveman P, Dominguez TP, Burke W, Dolan SM, Stevenson DK, Jackson FM, et al. [Explaining the Black-White Disparity in Preterm Birth: A Consensus Statement From a Multi-Disciplinary Scientific Work Group Convened by the March of Dimes](https://doi.org/10.3389/frph.2021.684207). Frontiers in Reproductive Health. 2021;3:684207.

3. David RJ, Collins JW. [Differing Birth Weight among Infants of U.S.-Born Blacks, African-Born Blacks, and U.S.-Born Whites](https://doi.org/10.1056/NEJM199710233371706). New England Journal of Medicine. 1997;337(17):1209–14.

4. Silva AA, Barbieri MA, Gomes UA, Bettiol H. [Trends in low birth weight: A comparison of two birth cohorts separated by a 15-year interval in Ribeirão Preto, Brazil.](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2305625) Bulletin of the World Health Organization. 1998;76(1):73–84.

5. Wilcox AJ. [On the importance–and the unimportance–of birthweight](https://doi.org/10.1093/ije/30.6.1233). International Journal of Epidemiology. 2001;30(6):1233–41.

6. Wilcox AJ, Snowden JM, Ferguson K, Hutcheon J, Basso O. [On the study of fetal growth restriction: Time to abandon SGA](https://doi.org/10.1007/s10654-024-01098-5). European Journal of Epidemiology. 2024 Mar;39(3):233–9.

7. Maruyama S, Heinesen E. [Another look at returns to birthweight](https://doi.org/10.1016/j.jhealeco.2019.102269). Journal of Health Economics. 2020 Mar;70:102269.

8. Ward WP. Birth Weight and Economic Growth: Women’s Living Standards in the Industrializing West. Chicago: University of Chicago Press; 1993.

9. Juliusdottir T, Steinthorsdottir V, Stefansdottir L, Sveinbjornsson G, Ivarsdottir EV, Thorolfsdottir RB, et al. [Distinction between the effects of parental and fetal genomes on fetal growth](https://doi.org/10.1038/s41588-021-00896-x). Nature Genetics. 2021 Aug;53(8):1135–42.

10. Solé-Navais P, Flatley C, Steinthorsdottir V, Vaudel M, Juodakis J, Chen J, et al. [Genetic effects on the timing of parturition and links to fetal birth weight](https://doi.org/10.1038/s41588-023-01343-9). Nature Genetics. 2023 Apr;55(4):559–67.

11. Warrington NM, Beaumont RN, Horikoshi M, Day FR, Helgeland Ø, Laurin C, et al. [Maternal and fetal genetic effects on birth weight and their relevance to cardio-metabolic risk factors](https://doi.org/10.1038/s41588-019-0403-1). Nature Genetics. 2019 May;51(5):804–14.

12. Paixao ES, Blencowe H, Falcao IR, Ohuma EO, Rocha A dos S, Alves FJO, et al. [Risk of mortality for small newborns in Brazil, 2011-2018: A national birth cohort study of 17.6 million records from routine register-based linked data](https://doi.org/10.1016/j.lana.2021.100045). The Lancet Regional Health – Americas. 2021 Nov;3.

13. Vilanova CS, Hirakata VN, de Souza Buriol VC, Nunes M, Goldani MZ, da Silva CH. [The relationship between the different low birth weight strata of newborns with infant mortality and the influence of the main health determinants in the extreme south of Brazil](https://doi.org/10.1186/s12963-019-0195-7). Population Health Metrics. 2019 Nov;17:15.

14. Barker DJP. [The Developmental Origins of Adult Disease](https://doi.org/10.1080/07315724.2004.10719428). Journal of the American College of Nutrition. 2004;23(sup6):588S–595S.

15. Costa DL. [Unequal at Birth: A Long-Term Comparison of Income and Birth Weight](https://doi.org/10.1017/S0022050700021690). The Journal of Economic History. 1998;58(4):987–1009.

16. Costa DL. [Race and Pregnancy Outcomes in the Twentieth Century: A Long-Term Comparison](https://doi.org/10.1017/S0022050704043086). The Journal of Economic History. 2004;64(4):1056–86.

17. Goldin C, Margo RA. [The poor at birth: Birth weights and infant mortality at Philadelphia’s almshouse hospital, 1848–1873](https://doi.org/10.1016/0014-4983(89)90026-0). Explorations in Economic History. 1989;26(3):360–79.

18. Steckel RH. [Birth weights and infant mortality among American slaves](https://doi.org/10.1016/0014-4983(86)90012-4). Explorations in Economic History. 1986;23(2):173–98.

19. Stein ZA, Susser M. Intrauterine Growth Retardation: Epidemiological Issues and Public Health Significance. Seminars in Perinatology. 1984;8(1):5–14.

20. Meloni M, Moll T, Issaka A, Kuzawa CW. [A biosocial return to race? A cautionary view for the postgenomic era](https://doi.org/10.1002/ajhb.23742). American Journal of Human Biology. 2022;34(7):e23742.

21. Travassos C, Williams DR. [The concept and measurement of race and their relationship to public health: A review focused on Brazil and the United States](https://doi.org/10.1590/S0102-311X2004000300003). Cadernos de Saúde Pública. 2004 Jun;20:660–78.

22. Nyarko KA, Lopez-Camelo J, Castilla EE, Wehby GL. [Explaining Racial Disparities in Infant Health in Brazil](https://doi.org/10.2105%2FAJPH.2012.301021). American Journal of Public Health. 2013;103(9):1675–84.

23. Wehby GL, Gili JA, Pawluk M, Castilla EE, López-Camelo JS. [Disparities in birth weight and gestational age by ethnic ancestry in South American countries](https://doi.org/10.1007/s00038-014-0639-6). International Journal of Public Health. 2015;60(3):343–51.

24. Leal M do C, Gama SGN da, Cunha CB da. [Desigualdades sociodemográficas e suas conseqüências sobre o peso do recém-nascido](https://doi.org/10.1590/S0034-89102006000300015). Revista de Saúde Pública. 2006 Jun;40:466–73.

25. Pollock EA, Gennuso KP, Givens ML, Kindig D. [Trends in infants born at low birthweight and disparities by maternal race and education from 2003 to 2018 in the United States](https://doi.org/10.1186/s12889-021-11185-x). BMC public health. 2021;21(1):1117.

26. Jasienska G. [Low birth weight of contemporary African Americans: An intergenerational effect of slavery?](https://doi.org/10.1002/ajhb.20824) American Journal of Human Biology: The Official Journal of the Human Biology Council. 2009;21(1):16–24.

27. Owens DC, Fett SM. [Black Maternal and Infant Health: Historical Legacies of Slavery](https://doi.org/10.2105/AJPH.2019.305243). American Journal of Public Health. 2019;109(10):1342–5.

28. Martins BNFL, Santos ESD, Fonseca FP, William WN, Oliveira TB de, Marta GN, et al. [The impact of colonialism on head and neck cancer in Brazil: A historical essay focussing on tobacco, alcohol and slavery](https://doi.org/10.1016/j.lana.2024.100690). The Lancet Regional Health – Americas. 2024 Mar;31.

29. Leimert KB, Olson DM. [Racial disparities in pregnancy outcomes: Genetics, epigenetics, and allostatic load](https://doi.org/10.1016/j.cophys.2019.12.003). Current Opinion in Physiology. 2020 Feb;13:155–65.

30. Adamo S. The Sick and the Dead: Epidemic and Contagious Disease in Rio de Janeiro, Brazil. In: Pineo R, Baer JA, editors. City of Hope: People, Protests, and Progress in Urbanizing Latin America, 1870-1930. Boulder, CO: Westview Press; 1998. p. 218–39.

31. Otovo OT. Progressive Mothers, Better Babies: Race, Public Health, and the State in Brazil, 1850-1945. Austin: University of Texas Press; 2016.

32. Roth C. A Miscarriage of Justice: Women’s Reproductive Lives and the Law in Early Twentieth-Century Brazil. Stanford, CA: Stanford University Press; 2020.

33. Telles LF da S. Teresa Benguela e Felipa Crioula estavam grávidas: maternidade e escravidão no Rio de Janeiro (1830-1888). São Paulo: Editora Unifesp; 2022.

34. Consortium SV. Trans-Atlantic Slave Trade: Estimates. Slave Voyages. https://www.slavevoyages.org/assessment/estimates; 2021.

35. Karasch MC. Slave Life in Rio de Janeiro, 1808-1850. Princeton, NJ: Princeton University Press; 1987.

36. Kiple KF. [The Nutritional Link with Slave Infant and Child Mortality in Brazil](https://doi.org/10.2307/2516096). The Hispanic American Historical Review. 1989;69(4):677–90.

37. Gr S, Holla R, Manjrekar P, Rao S. [Association of maternal and cord vitamin B12 levels with anthropometry in term neonates born to malnourished mothers in coastal South India](https://doi.org/10.12688/f1000research.150696.2). F1000Research; 2024.

38. Kareem O, Mufti S, Nisar S, Tanvir M, Muzaffer U, Ali N, et al. [Prevalence of Thiamine Deficiency in Pregnancy and its impact on fetal outcome in an area endemic for thiamine deficiency](https://doi.org/10.1371/journal.pntd.0011324). PLOS Neglected Tropical Diseases. 2023;17(5):e0011324.

39. Fischer B. A Poverty of Rights: Citizenship and Inequality in Twentieth-Century Rio de Janeiro. Stanford, CA: Stanford University Press; 2008.

40. Ball MC. Navigating Life and Work in Old Republic São Paulo. Gainesville: University of Florida Press; 2020.

41. Franken D. [Anthropometric History of Brazil, 1850-1950: Insights from Military and Passport Records](https://doi.org/10.1017/S0212610919000077). Revista de Historia Economica - Journal of Iberian and Latin American Economic History. 2019;37(2):377–408.

42. Benchimol JL. Dos micróbios aos mosquitos: febre amarela e a revolução pasteuriana no Brasil. Rio de Janeiro: Editora Fiocruz; 1999.

43. Hochman G. A era do saneamento: as bases da política de Saúde Pública no Brasil. 3rd ed. São Paulo: Hucitec Editora; 2013.

44. Loudon I. Death in Childbirth: An International Study of Maternal Care and Maternal Mortality, 1800-1950. Oxford: Clarendon Press; 1992.

45. Woods R. Death Before Birth: Fetal Health and Mortality in Historical Perspective. New York: Oxford University Press; 2009.

46. Barreto MRN, Oliveira SSR de. Cidade, assistência e saúde: as maternidades entre o privado e o público no subúrbio do Rio de Janeiro (1889-1930). Delaware Review of Latin American Studies. 2016;17(2).

47. Tuck E. [Suspending Damage: A Letter to Communities](https://doi.org/10.17763/haer.79.3.n0016675661t3n15). Harvard Educational Review. 2009;79(3):409–28.

48. Andrasfay T, Goldman N. [Intergenerational Change in Birthweight: Effects of Foreign-born Status and Race/Ethnicity](https://doi.org/10.1097/EDE.0000000000001217). Epidemiology. 2020;31(5):649.

49. Silveira MF, Victora CG, Horta BL, da Silva BGC, Matijasevich A, Barros FC. [Low birthweight and preterm birth: Trends and inequalities in four population-based birth cohorts in Pelotas, Brazil, 1982–2015](https://doi.org/10.1093/ije/dyy106). International Journal of Epidemiology. 2019;48(Supplement\_1):i46–53.

50. Organization WH. International Classification of Diseases, Eleventh Revision (ICD-11). Geneva: World Health Organization; 2022.

51. Wehby GL, López-Camelo JS. [Maternal Education Gradients in Infant Health in Four South American Countries](https://doi.org/10.1007/s10995-017-2327-7). Maternal and Child Health Journal. 2017;21(11):2122–31.

52. Wilcox AJ, Russell IT. Birthwieght and Perinatal Mortality: II. On Weight-Specific Mortality. International Journal of Epidemiology. 1983;12(3):319–25.

53. Conrado JR. Primeiros cuidados do recemnato. Rio de Janeiro: Typ. Aurora; 1924.

54. Souza RT, Vieira MC, Esteves-Pereira AP, Domingues RMSM, Moreira MEL, da Cunha Filho EV, et al. [Risk stratification for small for gestational age for the Brazilian population: A secondary analysis of the Birth in Brazil study](https://doi.org/10.1038/s41598-020-71252-y). Scientific Reports. 2020 Sep;10:14725.

55. Graham SL. House and Street: The Domestic World of Servants and Masters in Nineteenth-Century Rio de Janeiro. Austin: University of Texas Press; 1992.

56. da Silva HBM, de Cássia Ribeiro-Silva R, Junior EPP, Barreto ML, Paixão ES, Ichihara MY. [Syphilis in pregnancy and adverse birth outcomes: A nationwide longitudinal study in Brazil](https://doi.org/10.1002/ijgo.15561). International Journal of Gynecology & Obstetrics. 2024;166(1):80–9.

57. Carrara S. Tributo a vênus: a luta contra a sífilis no Brasil, da passagem do século aos anos 40. Rio de Janeiro: Editora Fiocruz; 1996.

58. Fontenelle JP. A saude publica no Rio de Janeiro: Districto Federal, 1937 e 1938. Rio de Janeiro;

59. Steckel RH. Birth Weights and Stillbirth in Historical Perspective. European Journal of Clinical Nutrition. 1998;52(S2):S16–20.

60. Roberts E, Wood P. [Birth weight and adult health in historical perspective: Evidence from a New Zealand cohort, 1907–1922](https://doi.org/10.1016/j.socscimed.2014.02.015). Social Science & Medicine. 2014;107:154–61.

61. Falcão IR, Ribeiro-Silva R de C, de Almeida MF, Fiaccone RL, dos S. Rocha A, Ortelan N, et al. [Factors associated with low birth weight at term: A population-based linkage study of the 100 million Brazilian cohort](https://doi.org/10.1186/s12884-020-03226-x). BMC Pregnancy and Childbirth. 2020;20(1):536.

62. Santana J da M, de Oliveira Queiroz VA, Pereira M, Paixão ES, Brito SM, dos Santos DB, et al. [Associations between Maternal Dietary Patterns and Infant Birth Weight in the NISAMI Cohort: A Structural Equation Modeling Analysis](https://doi.org/10.3390/nu13114054). Nutrients. 2021;13(11):4054.