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Infant birth weight in Brazil: A cross-sectional historical approach

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ABSTRACT

In 1888, Brazil became the last country in the Americas to abolish slavery. Historians have outlined the racialized health disparities of people of African descent in the post-abolition period. Epidemiologists have shown that twenty-first-century health disparities continue to mirror patterns from over a century ago. This cross-sectional analysis quantifies health disparities in a post-abolition maternity hospital using infant birth weight. It relies on hospital records on infants delivered between 1922 and 1926 ($n = 2845$) at the Maternidade Laranjeiras in the city of Rio de Janeiro, Brazil to run linear models assessing differences in infant birth weight by maternal skin color, age, number of pregnancies (parity), and nationality. African ancestry was correlated with lower birth weights. Infants born to Afro-descendant women had birth weights estimated to be 84 g lighter (p -value = 0.002 [95% CI -137, -32]) than infants born to Euro-descendant women. Among Afro-descendant women, infants born to Black (*preta*) women had birth weights estimated to be 100 g lighter (p -value = 0.001 [95% CI -160, -39]) and infants born to mixed-race (*parda*) women had birth weights estimated to be 70 g lighter (p -value = 0.022 [95% CI -130, -10]) than infants born to White women. The findings were likely the consequence of slavery's legacy, particularly race-based socioeconomic inequality – including more strenuous work schedules, poorer nutrition, and less sanitary living environments for people of African descent. The findings are consistent with current-day research on racialized health disparities in Brazil and demonstrate the importance of historical findings to public health research.

1. Introduction

This study analyzes infant birth weight as a proxy for general maternal, fetal, and infant 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 the city of Rio de Janeiro, Brazil between 1922 and 1926. It provides basic quantitative associations of the health status of the descendants of enslaved individuals in post-abolition Brazil, substantiating researcher's qualitative findings on health disparities stemming from slave societies, disparities that existed but did not wholly determine patients' lives.

Birth weight and its relationship to fetal and infant health have been a focus of public health research for over a century (Hughes et al., 2017; Schneider, 2017). 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 (Braveman et al., 2021; David and Collins, 1997; Hughes et al., 2017; Silva et al., 1998; Wilcox, 2001). 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 (Wilcox, 2001; Wilcox et al., 2024). Nonetheless, PTB is an important determinant of both LBW and lower birth weight in general (Maruyama and Heinesen, 2020).

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 (Braveman et al., 2021; David and Collins, 1997; Schneider, 2017; Ward, 1993). Recent genetic studies have detailed the specific alleles through which both the maternal and fetal genomes contribute to birth weight and gestational timing, while acknowledging the continued importance of non-genetic factors (Solé-Navais et al., 2023; Warrington et al., 2019).

Although not a causal mechanism, LBW is associated with higher rates of neonatal and infant mortality (Paixao et al., 2021; Vilanova et al., 2019). 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 (Barker, 2004). Yet, more recent genetic research and epidemiological studies

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employing instrumental variable (IV) analysis contest long-term trends associated with “fetal programming.” Warrington et al. (2019) argue that genetic effects and not intrauterine programming are associated with later life high blood pressure. Maruyama and Heinesen (2020) have found that although lower birth weight is associated with both infant mortality and other health issues in the neonatal period, its association with long-term health issues declines over time.

Historians, using hospital records, have shown how birth weight can be an indicator for the often-unmeasurable nutritional status of mothers in the past (Costa, 1998, 2004; Goldin and Margo, 1989; Steckel, 1986; Ward, 1993). Historically, women from more privileged groups had heavier infants than less-advantaged women (Stein and Susser, 1984; Ward, 1993).

The differences between and within groups both today and in the past have prompted research stratified by race. While race is a social construct and thus biological fiction, the social consequences of racism influence health and disease patterns, including birth outcomes, particularly in countries with high levels of race-based inequality (Meloni et al., 2022; Travassos and Williams, 2004). Contemporary studies in Brazil have shown that non-White mothers have higher odds of giving birth to LBW infants (Nyarko et al., 2013; Vilanova et al., 2019; Wehby et al., 2015). Non-White mothers also have infants with lower mean birth weights than their White counterparts (Leal et al., 2006). 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 (Pollock et al., 2021). 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 (Braveman et al., 2021; David and Collins, 1997).

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 (Jasienska, 2009; Owens and Fett, 2019; Steckel, 1986). 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 (Jasienska, 2009; Leimert and Olson, 2020). Historians have emphasized how race and socioeconomic status (SES) were deeply intertwined in post-abolition Brazil and thus disparities in literacy and access to education likely contributed to health gaps (Adamo, 1998; Ball, 2020; Franken, 2025). 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, fetal, and infant health outcomes (Adamo, 1998; Otovo, 2016; Roth, 2020; Telles, 2022).

Brazil imported over five million enslaved Africans over nearly four centuries (Consortium, 2021). Mortality rates that surpassed fertility rates, in addition to higher rates of individual manumission – the freeing of an enslaved person – helps explain Brazil’s reliance on the transatlantic slave trade. Brazil 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 punishment (Karasch, 1987). Excluding pregnant and nursing women, historians have argued that caloric intake for the enslaved population was sufficient in terms of quantity, yet it lacked key nutrients. Thus, the enslaved suffered from nutritional deficiencies, including thiamine, which was associated with infant mortality (Karasch, 1987; Kiple, 1989). Today, thiamine deficiency is correlated with lower birth weight and adverse perinatal outcomes (Kareem et al., 2023).

In the aftermath of abolition, no state-run efforts to incorporate

formerly enslaved peoples into economic, civic, or political life occurred (Fischer, 2008). Further, the state supported a policy of whitening in which elites believed that both racial mixture and White immigration would whiten the population (Ball, 2020; Stepan, 1991). Scholars have shown how Black and mixed-race Brazilians were incarcerated at higher rates, and had lower literacy levels, fewer employment opportunities, and worse health outcomes than their White and White immigrant counterparts (Adamo, 1998; Ball, 2020; Fischer, 2008; Otovo, 2016).

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 urban centers in Brazil’s southeastern and southern regions, including Rio de Janeiro (Franken, 2025). The early twentieth century was a period of advancement in both clinical care and public health in Brazil and globally. In cities, improved sanitation measures stemmed infectious disease outbreaks (Benchimol, 1999; Hochman, 2013). Infant mortality rates declined from the nineteenth century, although the major advancements including blood transfusions and antibiotics that resulted in sustained improvements in maternal and infant mortality and stillbirth rates only began in the late 1930s (Adamo, 1998; Loudon, 1992; Roth, 2020; Woods, 2009). Further, these advancements were concentrated in cities, and rural-urban and regional divides in maternal-infant health outcomes developed across Brazil that only decreased in the new Millennium (Scheper-Hughes, 1992; Victora et al., 2011).

A rural-urban and regional divide was also noticeable in fertility patterns. Women in the city of Rio de Janeiro started their fertility transition in the 1920s. In the early 1930s, the total fertility rate (TFR), which summarizes fertility rates across all women of reproductive age in a particular period, was less than 5 in Rio de Janeiro compared to 6 for São Paulo state (Gonçalves et al., 2019). By 1940, TFR for Rio de Janeiro had reached 3.8, compared to 4.7 for the city of São Paulo and 6.4 for Brazil (IBGE, 1952).

Maternidade Laranjeiras opened in 1904 and became the obstetrical teaching hospital at Rio de Janeiro’s medical school in 1918. In the mid-1920s, it was one of Rio de Janeiro’s three maternity hospitals for a total of 164 beds in a city of nearly 1.2 million inhabitants (Carvalho, 1924; Penteado, 1924; Roth, 2020).

Laranjeiras provided healthcare free of charge. The hospital was built in a neighborhood near weaving and textile factories that employed women workers. Scholars have found that most of its patients were neighborhood working-class women who were poor but not indigent. Most patients were women of color defined as either Black or mixed race, and most White patients were European immigrants (Barreto and Oliveira, 2016; Roth, 2020). Because it was the medical school’s teaching hospital, it also attracted difficult labors and deliveries, with women of all classes referred by a physician or midwife who initially attended the birth at home (Pinto Filho, 1923). Although other maternity hospitals in the 1920s had ambulatory systems, which provided home-based prenatal and labor and delivery care, Laranjeiras did not (Roth, 2020).

Because most of the hospital’s patients were working-class women from the surrounding neighborhood, its clientele was relatively representative of the city’s population, which was majority lower SES. But the hospital probably had a disproportionate number of difficult births given that medical practitioners referred obstructed labors to Laranjeiras. Further, in 1920s Rio de Janeiro, most mothers of all SES gave birth at home. At the turn of the century, around 99% of births were home-based. By the mid-1930s, around 80% of births occurred at home. For normal deliveries, wealthier women were least likely to give birth in a hospital (Roth, 2020).

In exploring differences in infant birth weight according to maternal skin color in early twentieth-century Rio de Janeiro, my aim is not to reify race as a genetic or epigenetic phenomenon (Meloni et al., 2022). Although differences between racialized groups existed, they were not immutable or due to race-based genetic differences. 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) (Tuck, 2009) but rather were living the consequences of slavery and socioeconomic and racial inequality.

2. Materials and methods

2.1. Data

This analysis draws on a unique dataset of 2845 recorded clinical visits, majority births, to Maternidade Laranjeiras in the city of Rio de Janeiro, Brazil between 1922 and 1926. I extracted data from the country’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), twin status (singleton or twin), and maternal reproductive history. Hospital clinicians erratically recorded civil status and gestational age, and thus I excluded them.

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 photographed 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 and code, are open access and reproducible.

2.2. Variables

2.2.1. Outcome

Birth weight. The outcome was birth weight measured as a continuous variable in grams for live births only (Andrasfay and Goldman, 2020; Costa, 1998, 2004; David and Collins, 1997; Leal et al., 2006; Silveira et al., 2019). In Supplemental_Materials, I also evaluated birth weight as a binary variable (either normal birth weight, NBW > 2500 g or low birth weight, LBW ≤ 2500 g), according to current WHO classifications (WHO, 2022).

2.2.2. 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. I also created a new skin-color dummy variable, combining Black and mixed-race patients as Afro-Descent and White patients as Euro-Descent.

Except at the extremes, racial classification in Brazil was, and continues to be, imprecise, as racial categories and skin color exist on a spectrum (Travassos and Williams, 2004). Using more general categories addresses imprecision by grouping all possible mothers of any African descent into one category. This method also aligns with recent studies, which look at all African-descended peoples as a group and then stratify by racial mixing (Nyarko et al., 2013; Wehby et al., 2015).

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

Maternal parity. The original hospital records divided maternal parity and gravidity 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, including nulliparous, primigravida, and primiparous (any woman giving birth for

the first time); and 2) multiparous, including 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.

2.2.3. 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 operative, indicating a cesarean section or embryotomy. I recategorized external manipulations including version and Mauriceau maneuver, coded as operator or natural by hospital records, as interventionist. I classified spontaneous abortion as a separate category.

Infant length. Hospital records included infant length in centimeters.

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.

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 g to avoid the inclusion of possible stillbirths that were misrecorded as live births in the original data (Nyarko et al., 2013; Wehby et al., 2015). The hospital records listed 20 neonatal deaths, which I included as live births. These numbers could have been higher, as the hospital only recorded deaths within the first week of life, when the infant was still hospitalized. I ran all linear models on singleton births only, excluding twins (David and Collins, 1997; Leal et al., 2006; Nyarko et al., 2013; Pollock et al., 2021; Silva et al., 1998; Silveira et al., 2019; Vilanova et al., 2019; Wehby et al., 2015).

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

Year. I constructed year fixed effects by including dummy variables for each year from 1923 to 1926. 1922 is the base year. The coefficient on these dummy variables is the year fixed effect, which indicates how the average birth weight is different from the base year.

2.3. 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).

The (MMR) is:

$$MMR = \frac{MD}{LB} \times 10,000$$

where maternal deaths (MD) are divided by 10,000 live births (LB). Today, MD are divided by 100,000 live births, but I use 10,000 live births in the denominator given the higher rates of deaths in the past and reporting uncertainties (Loudon, 1992). The MMR measures obstetric risk: the risk of death once a person is pregnant (WHO, 2006).

The SBR (excluding spontaneous abortion but including intrapartum

death defined here as stillbirth) for the hospital, is:

$$SBR = \frac{SB}{TB} \times 1,000$$

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

2.4. Statistical analysis

I used Ordinary Least Squares (OLS) to establish a relationship of maternal variables and infant birth weight. 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, skin color, parity, and nationality, and year fixed effects.

The simple linear regression model for modified ancestry is:

$$BW = \alpha + \beta_1 MA + \epsilon$$

whereas BW is birth weight in grams, α is the average birth weight, β_1 is the group deviation from the average birth weight, MA is maternal ancestry (Euro-descent, Afro-descent), and ϵ is the error term.

The multiple linear regression model for modified ancestry is:

$$BW = \alpha + \beta_1 MA + \beta_2 Par + \beta_3 Nat + \beta_4 Age + YrFE + \epsilon$$

whereas BW is birth weight in grams, α is the average birth weight, β_x are the group deviations from the average birth weight, MA is maternal ancestry (Euro-descent, Afro-descent), Par is parity (nulliparous or multiparous), Age is maternal age in years, YrFE is year fixed effect, and ϵ is the error term. Results for both models are displayed in Table 2.

The simple linear regression model for original skin color is:

$$BW = \alpha + \beta_1 MC + \epsilon$$

whereas BW is birth weight in grams, α is the average birth weight, β_1 is the group deviation from the average birth weight, MC is maternal skin color (White, Black, and mixed race), and ϵ is the error term.

The multiple linear regression model for original color is:

$$BW = \alpha + \beta_1 MC + \beta_2 Par + \beta_3 Nat + \beta_4 Age + YrFE + \epsilon$$

whereas BW is birth weight in grams, α is the average birth weight, β_x are the group deviations from the average birth weight, MC is maternal skin color (White, Black, and mixed race), Par is parity (nulliparous or multiparous), Nat is maternal nationality (Brazilian, Latin American, European, Middle Eastern), Age is maternal age in years, YrFE is year fixed effect, and ϵ 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 (Ball, 2020; Franken, 2025). 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 regressions from Models 1 and 2. Results for the sub-sample analysis are included in Table 2.

3. Results

Table 1 provides summary statistics for the dataset. Of hospital patients, 58% were of African descent (defined as *preta* or *parda*) and 42% were of European descent (*branca*). An average of census data for the city's female population's racial makeup between 1890 and 1940, years for which data exist, show that White women comprised 63%, mixed-race women 24%, and Black women 14% (with rounding errors) (Roth, 2020). Thus, at Laranjeiras, women of color were over-represented among hospital patients. First-time mothers (nulliparous), comprised 41%. Of all women, 84% were Brazilian, 15% were European immigrants, and the remaining were immigrants from other regions.

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 per 10,000 live births. The SBR was 83 stillbirths per 1000 live births.

The overall rate of LBW for infants born to Afro-descended mothers

Table 1
Summary statistics.

Characteristic	N	N = 2,845 ^a
Color	2695	
Black		763 (28%)
Mixed Race		788 (29%)
White		1144 (42%)
Ancestry	2695	
Afro-Descent		1551 (58%)
Euro-Descent		1144 (42%)
Parity	2836	
Multiparous		1681 (59%)
Nulliparous		1155 (41%)
Maternal Age	2783	25.3 (21.0, 29.0)
Combined Nationality	2773	
European		416 (15%)
Latin American		12 (0.4%)
Brazilian		2342 (84%)
Middle Eastern		3 (0.1%)
Birth Outcome	2761	
Abortion		89 (3.2%)
Interventionist		183 (6.6%)
Natural		2429 (88%)
Operative		60 (2.2%)
Maternal Outcome	2829	
Discharged		2802 (99%)
Death		23 (0.8%)
Hospital transferal		4 (0.1%)
Fetal Outcome	2666	
Live Birth		2445 (92%)
Stillbirth		221 (8.3%)
Sex	2534	
F		1153 (46%)
M		1381 (54%)
Birth Length (cm)	2405	48.3 (47.0, 50.0)
Birth Weight (g)	2384	3087 (2,800, 3450)
Black	643	3037 (2,750, 3250)
Mixed-Race	675	3064 (2,750, 3450)
White	950	3133 (2,850, 3500)
Afro-Descent	1318	3051 (2,750, 3350)
Euro-Descent	75	3164 (2,950, 3475)
Portuguese	272	3127 (2,819, 3500)
German	16	3172 (3,088, 3350)
Italian	12	3229 (3,075, 3663)
Spanish	20	3172 (2,875, 3350)
Russian	15	3183 (3,000, 3450)
White Brazilian	545	3131 (2,800, 3500)
Female	1074	3038 (2,750, 3350)
Male	1270	3137 (2,800, 3500)
Birth Weight Category	2234	
LBW		255 (11%)
NBW		1979 (89%)

^a n (%); Mean (IQR).

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 84 g lighter (p-value = 0.002 [95% CI -137, -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 g lighter (p-value = 0.001 [95% CI -160, -39]) than White mothers, while mixed-race mothers gave birth to infants weighing on average 70 g lighter (p-value = 0.022 [95% CI -130, -10]) 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 (Stein and Susser, 1984; Wilcox and Russell, 1983). 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 (Maruyama and Heinesen, 2020). Applied to these data, an 84 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 than multiparous women, an association recognized by physicians at the time and found in both other historical studies and today (Conrado, 1924; Costa, 1998; Souza et al., 2020). Age and nationality were not significant. The year fixed effects variable demonstrates that birthweights were highest in 1922.

4. Discussion

In general, maternal, fetal, and infant outcomes were not better in

Table 2
Model 1 and 2 Results (Dependent variable: Birth weight in grams).

Characteristic	Model 1			Sub-Model 1			Model 2			Sub-Model 2		
	Beta ^a	SE ^b	T-Statistic	Beta ^a	SE ^b	T-Statistic	Beta ^a	SE ^b	T-Statistic	Beta ^a	SE ^b	T-Statistic
(Intercept)	3188***	17.7	180	3171***	22.2	143	3119***	61.9	50.4	3121***	66.4	47.0
Age							2.5	2.23	1.14	2.7	2.44	1.11
ModifiedColor												
Euro-Descent	-	-	-	-	-	-	-	-	-	-	-	-
Afro-Descent	-99***	23.0	-4.31	-83**	26.5	-3.13	-84**	27.0	-3.13	-86**	26.4	-3.24
ModifiedNationality												
Brazilian							-	-	-	-	-	-
European							27	36.6	0.751			
Latin American							80	166	0.485			
Middle Eastern							571	494	1.16			
ModifiedStatus												
Nulliparous							-	-	-	-	-	-
Multiparous							115***	25.3	4.57	106***	26.9	3.95
Year												
1922							-	-	-	-	-	-
1923							-102**	35.1	-2.90	-92*	37.5	-2.44
1924							-110**	38.1	-2.89	-125**	40.7	-3.07
1925							-70*	33.9	-2.06	-71	36.2	-1.96
1926							-122*	48.9	-2.49	-115*	51.8	-2.22
No. Obs.	1920			1611			1920			1611		
R ^b	0.010			0.006			0.033			0.028		

^a *p < 0.05; **p < 0.01; ***p < 0.001.

^b SE = Standard Error.

Table 3
Model 3 and 4 Results (Dependent variable: Birth weight in grams).

Characteristic	Model 3			Model 4		
	Beta ^a	SE ^b	T-Statistic	Beta ^a	SE ^b	T-Statistic
(Intercept)	3188***	17.7	180	3236***	70.6	45.8
Age				2.5	2.23	1.12
Color						
White	-	-	-	-	-	-
Black	-112***	27.6	-4.05	-100**	30.9	-3.22
Mixed Race	-88**	27.2	-3.23	-70*	30.5	-2.30
ModifiedNationality						
Brazilian				-	-	-
European				28	36.6	0.753
Latin				80	166	0.484
American						
Middle Eastern				571	494	1.16
ModifiedStatus						
Multiparous				-	-	-
Nulliparous				-116***	25.3	-4.60
Year						
1922				-	-	-
1923				-101**	35.1	-2.89
1924				-111**	38.1	-2.92
1925				-69*	33.9	-2.03
1926				-121*	48.9	-2.48
No. Obs.	1920			1920		
R ^b	0.010			0.034		

^a *p < 0.05; **p < 0.01; ***p < 0.001.

^b SE = Standard Error.

the Maternidade Laranjeiras than among the city's wider population. Between 1922 and 1926, the clinic's MMR was 94 maternal deaths per 10,000 live births compared to 66 maternal deaths per 10,000 live births for the city (Roth, 2020). Hospital rates probably reflected a registration effect (Loudon, 1992), as medical personnel recorded all births and deaths, whereas the city's vital statistics were still haphazardly collected in the 1920s (Roth, 2020). The same pattern holds for the SBR, which was 85 stillbirths per 1000 live births for Laranjeiras and 74 stillbirths per 1000 live births for the city (Roth, 2020).

This study found that women of African descent in early twentieth-century Rio de Janeiro had infants with lower birth weights and

higher rates of LBW than their White counterparts, perhaps indicative of higher rates of PTB. Wilcox (2001) 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 (Hughes et al., 2017). 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 even as epidemiologists began to differentiate between small-for-gestational age (SGA, now FGR) and PTB in the 1970s (Hughes et al., 2017; Wilcox, 2001). Physicians in early twentieth-century Rio de Janeiro defined low birth weight as > 2500g and normal birth weight as between 3000 and 3500 g (Conrado, 1924).

Regardless, LBW was more dangerous in the past given that the probability of surviving the neonatal period was lower than today due to higher mortality rates and less effective medical interventions (Costa, 1998; Maruyama and Heinesen, 2020; Roth, 2020).

Table 4 provides the mean birth weights for the Laranjeiras sample, stratified by sex and maternal skin color in comparison with both current-day mean 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 compared to other historical samples except for estimated enslaved birth weights in the antebellum US South (Steckel, 1986), which scholars have since called into question for being too low (Costa, 2004). Historically, these babies were very light when compared to other urban centers across the globe. Black infants born at Laranjeiras were 146 g lighter than Black infants born at the Johns Hopkins hospital during an equivalent period. They were 85 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, 290 g lighter than White infants born at the Johns Hopkins hospital during an equivalent period (3423 g). They were 53 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 today.

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 period (Costa, 1998, 2004; Goldin and Margo, 1989). Across populations, relatively high mean birth weights in the nineteenth and early twentieth centuries could be an artifact of high stillbirth rates, which selected upon fetuses that were already small and unhealthy (Costa, 1998, 2004; Schneider, 2017). Today, PTB and lower birth weight infants that might have died in utero 100 years ago survive, 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 (Solé-Navais et al., 2023; Warington et al., 2019) and maternal age, parity, birth spacing, and gestational age all condition birth weight (Stein and Susser, 1984), the intrauterine environment remains a critical determinant. Here, maternal age was not significant, although multiparous mothers had infants with higher birth weights. The data did not provide information on birth spacing or gestational age.

What about external factors related to poverty? Infectious disease, alcohol or drug use, smoking, heavy physical work, and inadequate prenatal care influence birth weight (Schneider, 2017; Stein and Susser, 1984). Maternal nutrition can too, although the relationship is nonlinear in that the pregnant body protects the fetus at the expense of the mother, and a malnutrition threshold must be met before adverse effects occur (Costa, 1998; Steckel, 1986; Stein and Susser, 1984). Other health

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
Ribeirão Preto, São Paulo, Brazil	1994	3115	Silva et al., 1998
Rio de Janeiro (Black singletons, mothers < K-12)	1999–2001	3122	Leal et al., 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 et al., 2006
São Paulo, Brazil (live)	1993–98	3155	Monteiro et al., 2000
Pelotas, Rio Grande do Sul, Brazil (live singletons)	2004	3167	Silveira et al., 2019
Pelotas, Rio Grande do Sul, Brazil (live singletons)	1993	3169	Silveira et al., 2019
Baltimore (Black singletons)	1897–1935	3183	Costa, 2004
Rio de Janeiro (Black singletons, mothers ≥ K-12)	1999–2001	3185	Leal et al., 2006
Rio de Janeiro (White singletons, mothers < K-12)	1999–2001	3186	Leal et al., 2006
Pelotas, Rio Grande do Sul, Brazil (live singletons)	2015	3198	Silveira et al., 2019
Pelotas, Rio Grande do Sul, Brazil (live singletons)	1982	3201	Silveira et al., 2019
Rio de Janeiro (Mixed-race singletons, mothers ≥ K-12)	1999–2001	3210	Leal et al., 2006
Rio de Janeiro (White singletons, mothers ≥ K-12)	1999–2001	3218	Leal et al., 2006
Ribeirão Preto, São Paulo, Brazil	1978–79	3234	Silva et al., 1998
Boston (in hospital)	1886–1900	3330	Ward, 1993
Philadelphia (all)	1848–73	3375	Goldin and Margo, 1989
Philadelphia (live)	1848–73	3403	Goldin and Margo, 1989
Wellington, NZ (singleton live female)	1907–22	3403	Roberts and Wood, 2014
Baltimore (white singletons)	1897–1935	3423	Costa, 2004
New York (singletons)	1910–31	3463	Costa, 1998
Wellington, NZ (singleton live)	1907–22	3467	Roberts and Wood, 2014
Boston (at home)	1884–1900	3479	Ward, 1993
Boston	1872–1900	3480	Ward, 1993
Wellington, NZ (singleton live male)	1907–22	3531	Roberts and Wood, 2014

*All values are sample means except the Steckel estimate, which is a regression coefficient.

problems related to maternal undernutrition during pregnancy depend on gestational period. Research on the Dutch famine during World War II shows that adult health problems of infants born to mothers who were pregnant during the famine depended on the gestational period during which maternal undernutrition occurred (Roseboom et al., 2006). But overall nutritional deficiencies that were found among slave populations in nineteenth-century Rio de Janeiro were associated with lower birth weights and infant mortality (Karasch, 1987; Kareem et al., 2023; Kiple, 1989). 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 nutritional deficiencies continued (Adamo, 1998). The late abolition of slavery could have contributed to differences in the historical mean birth weights in Table 4.

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 and work throughout the third trimester, as washerwomen, domestic help, and street vendors (Graham, 1992; Roth, 2020). These

same women might have lived in crowded housing arrangements without running water (Fischer, 2008; Graham, 1992; Roth, 2020). Outbreaks of epidemic disease like malaria and yellow fever might have had differential effects on women based on their living and working conditions (Benchimol, 1999). Generalized poverty might have influenced women of African descent's nutrition, disease environments, physical routines, and ability to access prenatal care. Comparing these factors to those present in other locations might further explain the historical differences in mean birth weights.

Because the hospital records excluded information on maternal health factors, we don't know which contributed to racial disparities in 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. Syphilis results in adverse birth outcomes including increased risk of LBW and PTB (da Silva et al., 2024). The clinical records only sporadically recorded syphilis rates in women's reproductive histories or fetal outcomes (maceration). Physicians viewed it as an important cause of adverse health outcomes (Penteado, 1924; Fontenelle). City-wide rates from the 1930s can provide prevalence of infection among pregnant women. Of all prenatal syphilis exams performed between 1935 and 1938 at public clinics or hospitals, unadjusted for maternal skin color, around 8% were positive (Fontenelle).

4.1. Strengths and limitations

This study contributes heretofore unpublished hospital records from one of Brazil's most important public maternity hospitals in a major early twentieth-century city, a hospital that remains in operation today. It provides quantitative evidence of racialized disparities in maternal, fetal, and infant health. These findings are thus useful to compare to present-day research to assess the extent of progress in outcomes. They also provide direct evidence of historical racial disparities in Brazil, rare for this period, and thus complement descriptive historical studies.

All models based on historical data must contend with limited sample sizes, missing data, and imprecise measures of health and nutrition (Ball, 2020; Franken, 2025; Roberts and Wood, 2014; Steckel, 1998; Ward, 1993). Physicians could have introduced systematic measurement error when weighing newborns, 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 (Conrado, 1924). Thus, an upward bias to the mean through the inclusion of clothing or blankets for all infants seems unlikely. Physicians most likely did not weigh infants of one skin color differently than those of another given that Laranjeiras was a major medical school's teaching hospital. If any upward bias existed, weights were lower than presented here.

Additionally, physicians could have introduced rounding error as all birth weights were rounded to the nearest 50 g. Any systematic bias in any direction for any group of infants would have been at the hospital level since multiple clinicians weighed babies over the five-year period. Yet, the theoretical upper bound on bias is 50 g, and my results show a difference greater than 50 g. Scholars such as Goldin and Margo (1989) for birth weights in Philadelphia and Steckel (1994) for adult heights in the United States have shown that heaping did not systematically bias the mean. I assume the same.

Two sets of missing data are notable. First, hospital records excluded maternal marital status (included in only 0.4% of records). As scholars have found that marital status was a good proxy for SES (Costa, 2004; Goldin and Margo, 1989), the hospital's exclusion of this variable precludes a full understanding of mothers' SES.

A second, major limitation was the hospital records' exclusion of gestational age. Thus, the birth weight variable captures both smaller babies born at term, whether with or without FGR, and PTB. (Falcão

et al., 2020). 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 (Falcão et al., 2020; Wilcox, 2001; Wilcox et al., 2024). 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. The factors discussed here could have contributed PTB, to FGR, or to both.

Today, lower mean birth weights between populations are not necessarily associated with worse health outcomes (Wilcox, 2001). Yet continued differences between racialized groups hints at the possible role of socio-economic inequity and racism in determining 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 (Maruyama and Heinesen, 2020). 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. Some scholars argue that reductions in perinatal mortality over the past 150 years have occurred due to a reduction of deaths among the most at-risk fetuses and neonates, not to an improvement in overall fetal health (Schneider, 2017).

Finally, birth weights studied historically are as important for understanding their mother's past lives as for predicting perinatal or neonatal outcomes (Ward, 1993). Although studies have called into question the utility of birth weight as a marker of fetal health (Schneider, 2017; Wilcox, 2001), in many historical contexts, it remains one of the only available indicators.

Lack of data on maternal nutrition, health, work routine, civil status, 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 (Costa, 2004; Ward, 1993). Given the paucity of historical understandings of current-day health disparities in maternal, fetal, and infant health, this paper demonstrates the need for more research into quantitative associations between socio-demographic categories and health in the past, particularly in non-North American and Western European countries.

5. Conclusion

This study has shown that lower birth weights were associated with Afro-descended women giving birth in the Maternidade Laranjeiras in the city of Rio de Janeiro, Brazil between 1922 and 1926, suggesting 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 both historical and present-day studies on racialized disparities in birth weight in Rio de Janeiro, demonstrating how racial inequality in health outcomes has persisted over time.

Ethics

I have read and adhere to the Duties of Authors.

Declaration of competing interest

I have nothing to declare.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.socscimed.2025.117677>.

Data availability

All data and code are available and reproducible: <https://github.com/cp-roth/Roth-ML-project.git>

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