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Racial Inequities in the Control of Hypertension and the Explanatory Role of Residential Segregation: a Decomposition Analysis in the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil)

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Abstract

The mechanisms underlying racial inequities in uncontrolled hypertension have been limited to individual factors. We investigated racial inequities in uncontrolled hypertension and the explanatory role of economic segregation in the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil). All 3897 baseline participants with hypertension (2008–2010) were included. Uncontrolled hypertension (SBP ≥ 140 mmHg or DBP ≥ 90 mmHg), self-reported race (White/Brown/Black people), and neighborhood economic segregation (low/medium/high) were analyzed cross-sectionally. We used decomposition analysis, which describes how much a disparity would change (disparity reduction; explained portion) and remain (disparity residual; unexplained portion) upon removing racial differences in economic segregation (i.e., if Black people had the distribution of segregation of White people, how much we would expect uncontrolled hypertension to decrease among Black people). Age- and gender-adjusted prevalence of uncontrolled hypertension (39.0%, 52.6%, and 54.2% for White, Brown, and Black participants, respectively) remained higher for Black and Brown vs White participants, regardless of economic segregation. Uncontrolled hypertension showed a dose–response pattern with increasing segregation levels for White but not for Black and Brown participants. After adjusting for age, gender, education, and study center, unexplained portion (disparity residual) of race on uncontrolled hypertension was 18.2% (95% CI 13.4%; 22.9%) for Black vs White participants and 12.6% (8.2%; 17.1%) for Brown vs White participants. However, explained portion (disparity reduction) through economic segregation was − 2.1% (− 5.1%; 1.3%) for Black vs White and 0.5% (− 1.7%; 2.8%) for Brown vs White participants. Although uncontrolled hypertension was greater for Black and Brown vs White people, racial inequities in uncontrolled hypertension were not explained by economic segregation.

Keywords Racial inequities · Economic residential segregation · Decomposition analysis · Hypertension control · Brazil

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Introduction

High blood pressure is a leading global health risk [1]. Despite the availability of preventive interventions and low-cost, effective antihypertensive medications, hypertension remains largely untreated and uncontrolled, particularly among marginalized social groups [2, 3]. In the US, African American people have a disproportionately high prevalence of hypertension, poorer blood pressure control, and increased risk of blood pressure-related complications, compared to White people [3, 4]. In Brazil, a multiracial developing society with the world's fifth largest population [5, 6], stark health inequities exist unfavorable to people who identify their race/skin color as Black or Brown ("Pardo") compared to White people [5, 7, 8]. Black and Brown Brazilians have lower income and education, along with high crime rates in the communities in which they live [6, 9]. They are also less likely to have access to adequate medical care and to have their high blood pressure detected, treated, and controlled, compared to White Brazilians [10].

Despite the large body of evidence on racial inequities in the control of hypertension [2–4], the potential mechanisms underlying racial inequities in uncontrolled hypertension have been less studied. Explanations have been limited to individual-level factors related to low socioeconomic status (SES), poor diet, sedentary lifestyle, obesity, and comorbidities [3, 11]. However, these factors are entangled within unequal socioenvironmental contexts, which are determined by differences in the distribution of social, economic, and political resources [2]. Thus, intervening on the social contexts might be highly effective for reducing racial health inequities. Moreover, a growing body of literature suggests that these individual factors do not fully explain racial inequities in hypertension control [12–14].

Residential segregation is defined as "the systematic separation of individuals into different neighborhoods based on social class or race" [15]. Economically segregated areas might lead to uncontrolled hypertension through unequal neighborhood conditions (e.g., less primary health care availability and lower access to medications, poor physical, social, and food environments) and social stress, ultimately driving unhealthy behaviors such as smoking, physical inactivity, and increased alcohol and sodium consumption [2, 13, 15, 16]. In Brazil, spatial inequalities in health by race and SES exist, due to historical discriminatory policies and practices as a result of structural racism [5, 9]. Thus, Black and Brown Brazilians are more likely than White Brazilians to live in economically segregated areas [15], which may contribute to racial inequities in hypertension management and control.

Evidence from US studies showed that residential segregation contributes to racialized health inequities in a number of outcomes such as hypertension [17], incident cardiovascular disease [16], obesity [18], and adverse birth outcomes [19], accounting for 4–25% of the racial inequities in health. However, this evidence is focused on racial segregation, and economic segregation has been very poorly investigated. In the Brazilian context, a small set of studies have found that more economic segregation is associated with poorer health-related outcomes [15, 20, 21] and only one has focused on racial health inequities [22]. Studying residential segregation in Brazil and its role on racial health inequities is important because, in contrast to the US, Brazil has a different spatial patterning of inequalities characterized by the peripheralization of the Black and Brown communities [15], and a different racial classification based on a white-to-black skin color continuum [23]. Moreover, Brazil is the country with the largest Black population outside the African country (56.1% of Brazilian population self-declare as Black or Brown people, or 119.3 million people) [24].

Previous studies on residential segregation and cardiovascular outcomes have focused on metropolitan area-level segregation measures (e.g., measured at the metropolitan area, county, or city level), which are unable to capture the experience of segregation in an individual's actual neighborhood [25]. In addition, neighborhood-level segregation studies have used income or racial composition as a proxy for segregation. However, it does not take into account the income or racial composition of the larger surrounding area, neither how income or racial groups are distributed in space [15, 16, 25]. Using a neighborhood-level segregation measure that reflects both the contextual and spatial aspects of segregation [16, 26], this study addresses the limited research on the impact of economic residential segregation on racial health inequities, outside of the US context.

Our aims were to investigate (1) racial inequities in uncontrolled hypertension and (2) the explanatory role of economic residential segregation, in a large urban setting in Brazil, the multicenter Longitudinal Study of Adult Health (ELSA-Brasil). We have used a decomposition technique [27, 28] that identifies how inequities might change by intervening on the explanatory variable (i.e., if we were to eliminate racial differences in the explanatory variable economic residential segregation, how much we would expect racial inequities in the outcome uncontrolled hypertension to be mitigated). We hypothesized that (1) Black and Brown people have a higher prevalence of uncontrolled hypertension compared to White people and (2) economic residential segregation partially explains racial inequities in uncontrolled hypertension.

Materials and Methods

Study Population

ELSA-Brasil is a large multiracial, multicenter prospective cohort study [29]. At baseline (2008–2010), 15,105 active or retired employees (35–74 years) of universities or research institutions were enrolled in six Brazilian cities. The present study included all participants with hypertension at baseline and geocoded information (eligible population). Self-declared Asian descent ($N = 102$) and Brazilian Indigenous ($N = 38$) participants were excluded due to small numbers. Therefore, we analyzed 3897 subjects with hypertension at baseline (Fig. 1). Analyzed and non-analyzed subjects were compared in a supplementary table (Online Resource 1).

Measures

Outcome

Systolic and diastolic blood pressure (SBP and DBP) were measured using standardized procedures [30]. Three measurements were taken and the average of the second and third measurements was considered for analyses. *Uncontrolled hypertension* was defined as SBP ≥ 140 mmHg or DBP ≥ 90 mmHg (for those with diabetes or chronic kidney disease, SBP ≥ 130 mmHg or DBP ≥ 80 mmHg), according to the Seventh Report of the Joint National Committee's (JNC-7) recommendations [30], among all participants with hypertension (SBP ≥ 140 mmHg or DBP ≥ 90 mmHg or use of medication to treat high blood pressure) at baseline.

Exposure

Self-reported *race/skin color* was assessed according to the classification officially adopted in the IBGE Brazilian Census: White, Brown (or "Pardo"), Black, Asian (people of Asian descent), or Indigenous (Brazilian Indigenous) people.

Explanatory Variable

Local neighborhood environments in ELSA-Brasil were based on study-defined geographic boundaries, which correspond to clusters of contiguous and socioeconomically homogeneous census tracts, with a minimum population size of 5000 inhabitants, comparable in size to US census tracts commonly used as proxies in neighborhood effect research [15]. *Economic residential segregation* (from here on, economic segregation) was assessed for all study-defined neighborhoods located within the metropolitan boundaries of the six ELSA-Brasil centers. We used the Getis-Ord Local G_i^* statistic (G_i^* statistic) [26], a spatial approach that has been used in recent epidemiological investigations of segregation and cardiovascular disease [15, 16]. The G_i^* statistic is a spatially weighted z-score that represents how much a neighborhood's income composition deviates from the larger metropolitan area in which the neighborhood is embedded, also accounting for the spatial clustering of segregation (i.e., poor neighborhoods surrounded by other poor neighborhoods will have higher segregation values) [15].

For this study, the G_i^* statistic was based on the proportion of heads of households in a neighborhood earning a monthly income of 0–3 minimum wages (< $900 USD in 2010) and was derived using data from the 2010 IBGE Brazilian Census. G_i^* scores were calculated for each neighborhood using the hot spot analysis tool in ArcGIS®, based on the equation:

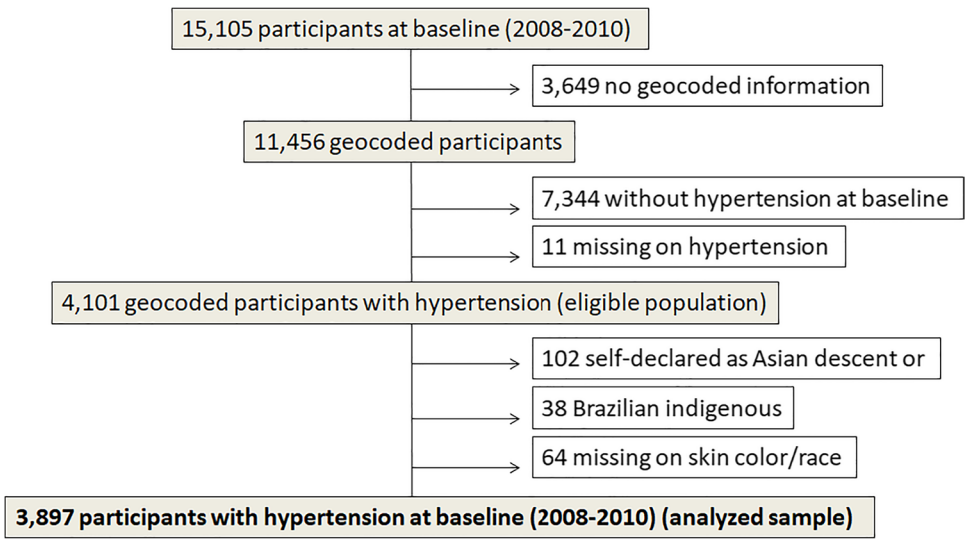

Fig. 1 Flowchart for participants' selection. ELSA-Brasil (2008–2010)

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j}x_j - \overline{X}\sum_{j=1}^{n} w_{i,j}}{S\sqrt{\frac{[n\sum_{j=1}^{n} w_{i,j}^2 - \left(\sum_{j=1}^{n} w_{i,j}\right)]}{n-1}}}$$

where x_j represents the proportion of households with 0–3 minimum wages for neighborhood j; w_{ij} is the spatial weight between feature i and j; n is the total number of neighborhoods within the metropolitan area; $\overline{X}$ is the mean proportion of households with 0–3 minimum wages for the metropolitan area; and *S* is the standard deviation.

Large, positive scores represent more economically segregated neighborhoods (i.e., higher proportion of households with 0–3 minimum wages), while low negative scores represent less economically segregated neighborhoods (i.e., lower proportions of households with 0–3 minimum wages). Based on the distribution of the sample, we created categories of segregation that represent neighborhoods with segregation scores ± 1 standard deviation above the metropolitan mean (high, G_i^* statistic ≥ 1; medium, between 1 and − 1; low, ≤ − 1) [15].

Potential Confounders

According to the proposed causal model (Fig. 2), the minimally sufficient conditioning set of covariates required for estimating the effect of segregation on uncontrolled hypertension includes *age* (continuous), *gender*, *education* (university, secondary, elementary, < elementary), and *study center* (Salvador, Vitória, Belo Horizonte, Rio de Janeiro, São Paulo, Porto Alegre), which represent confounders of the explanatory variable-outcome relationship. Because we are not envisioning an intervention on race, we do not need to define confounders for race.

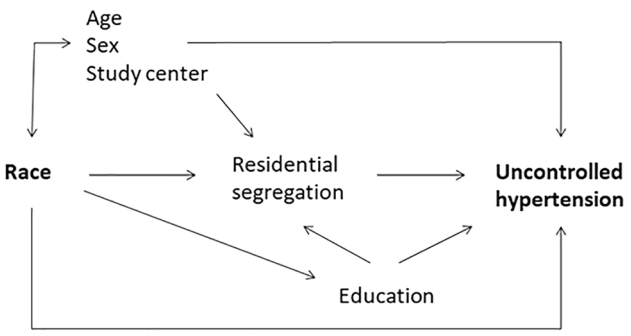

Fig. 2 Causal structure of the hypothesized effects of race and residential segregation on uncontrolled hypertension. ELSA-Brasil (2008–2010)

Additional Covariates

For descriptive purposes, we used *maternal education* (university, secondary, elementary, < elementary), *per capita family income* (in USD, continuous), *occupation* (manual/non-manual), *private health insurance* (yes/no), *obesity* (yes/no), *diabetes* (self-reported or use of antidiabetic medication or fasting glucose ≥ 126 mg/dL or glucose tolerance test ≥ 200 mg/dL or glycated hemoglobin ≥ 6.5%, yes/no), *chronic kidney disease* (yes/no), *physical activity* (minutes/week, continuous), *sodium consumption* (12-h urine sample in mg, continuous), and *current smoking* (yes/no).

Statistical Analysis

In this cross-sectional analysis, descriptive results were obtained using chi-square test and ANOVA on group differences. To examine the effect of race on uncontrolled hypertension as explained by economic segregation, we used a decomposition technique based on interventional effects using standardization [27, 28]. A strength of this method is the possibility of estimating non-biased effects even in the presence of explanatory variable-outcome confounders affected by race (e.g., education in Fig. 2). Using a counterfactual framework, this method yields a disparity reduction (explained portion) and a disparity residual (unexplained portion) upon intervening on the explanatory variable (economic segregation). Conceptually, it maps to a randomized trial of an intervention that removes age- and gender-adjusted disparities in economic segregation by assigning, e.g., Black people, to certain neighborhoods with the distribution of economic segregation of, e.g., White people of the same age and gender. In other words, it expresses how changes in the explanatory variable could reduce racial disparities in the outcome (i.e., how disparities might change upon equalizing the explanatory variable distribution across race groups within levels of age and gender). This sort of analysis is valuable for evidence-based policy to reduce racial inequities in uncontrolled hypertension by targeting racial disparities in economic segregation [27].

Separate analysis was carried out for Black (or Brown) participants vs White participants. An adaptation of "Ratio-of-Mediator Probability Weighting" [28] was used to simultaneously standardize age, gender, and residential segregation (low, medium, high) across race groups, while accounting for confounding by age, gender, study center, and education. Ninety-five percent confidence intervals were obtained using the non-parametric bootstrap with the percentile method.

The age- and gender-standardized prevalence difference was estimated via a generalized linear regression model with robust standard errors, using stabilized weights [31] formed from the marginal probability of belonging to

a particular racial group, first marginally (for weights' numerator), and then conditionally on age and gender (for the weights' denominator), referred to as "race weights." To enable a contrast of observed age- and gender-standardized prevalence differences between Black (or Brown) participants as observed before vs White participants after further standardization for segregation, we multiplied the "race weights" by "segregation weights" that were formed from the conditional probability of belonging to a particular category of segregation given age and gender (for the weights' numerator, among White participants) and additionally given study center and education (for the weights' denominator, among Black (or Brown) participants). We then estimated the explained portion of the disparity (disparity reduction) via a generalized linear regression model with robust standard errors, with one copy of Black (or Brown) subjects using race weights only, and the other copy of Black (or Brown) subjects using the final weights. We used a similar procedure to obtain the unexplained portion of the disparity (disparity residual) using data from Black (or Brown) subjects and White subjects. The comparison of Black (or Brown) subjects under observed conditions to hypothetical conditions is analogous to the concept of population impact (a generalization of the population attributable risk).

Secondary analyses considering only participants with hypertension treated were performed. Analyses were carried out using R (version 3.5.0) (codes available upon request).

Results

Of the 3897 baseline participants with hypertension (49.4% White, 28.8% Brown, 21.9% Black people), 46.2% had uncontrolled hypertension (39.5% in White, 52.7% in Brown, and 52.8% in Black people). Prevalence of antihypertensive medication was higher among White participants and lower among Brown and Black participants. White people were more likely to live in low segregated neighborhoods, whereas Brown and Black people were more likely to live in high segregated neighborhoods. Mean economic segregation scores (range − 6.61 to 3.36) were also higher for Black and Brown participants compared to White participants. White respondents were older, mostly male, higher educated and showed lower mean blood pressure, compared to Brown and Black respondents. Individuals with uncontrolled hypertension were more likely to be male and lower educated, compared to individuals with controlled hypertension (Table 1). Additional descriptive results showed that, compared to White people, Black and Brown people had

Table 1 Baseline characteristics of the study sample, by race and hypertension control, ELSA-Brasil (2008–2010), $N = 3897$

	All sample[a]	Race/skin color				Hypertension control		
		White	Brown	Black	p-value[b]	Controlled	Uncontrolled[c]	p-value[d]
N of participants (%)	3897	1924 (49,4)	1121 (28.8)	852 (21.9)	-	2096 (53.8)	1801 (46.2)	-
Uncontrolled hypertension, %	46.2	39.5	52.7	52.8	< 0.001	-	-	-
Antihypertensive medication use, %	77.6	79.6	74.2	77.5	0.003	100.0	51.5	< 0.001
Residential segregation[e], %								
Low (− 6.61 to − 1.00)	53.8	68.8	44.1	32.5	< 0.001	57.2	49.7	< 0.001
Medium (− 0.99 to 0.99)	29.1	22.6	32.8	39.0		26.6	32.1	
High (1.00 to 3.36)	17.1	8.6	23.1	28.5		16.2	18.2	
Local Gi* statistic, mean (SD)	− 1.3 (2.2)	− 2.0 (2.1)	− 0.8 (2.1)	− 0.3 (1.9)	< 0.001	− 1.47 (2.2)	− 1.11 (2.1)	< 0.001
Age in years, mean (SD)	56.4 (8.8)	57.6 (8.9)	55.2 (8.6)	55.5 (8.5)	< 0.001	56.6 (8.6)	56.2 (9.1)	0.12
Gender, male %	49.3	53.5	50.0	38.7	< 0.001	43.8	55.6	< 0.001
Education, %								
University degree	49.6	69.0	35.3	24.9	< 0.001	56.2	42.1	< 0.001
Complete secondary school	34.7	23.4	42.4	49.9		32.0	37.1	
Complete elementary school	8.2	4.0	10.4	14.7		6.4	10.3	
Incomplete elementary school	7.5	3.6	11.9	10.6		5.5	9.8	
Systolic blood pressure (mmHg), mean (SD)	133.9 (18.6)	130.8 (17.7)	135.4 (18.7)	137.6 (19.8)	< 0.001	120.7 (10.7)	148.6 (14.2)	< 0.001
Diastolic blood pressure (mmHg), mean (SD)	82.7 (11.6)	81.3 (11.3)	83.9 (11.7)	84.3 (11.8)	< 0.001	75.5 (7.8)	91.2 (9.4)	< 0.001

[a]All participants with hypertension, [b]p-value for race differences, [c]participants with hypertension with SBP ≥ 140 or DBP ≥ 90 mmHg (for those with diabetes or chronic kidney disease: SBP ≥ 130 or DBP ≥ 80 mmHg), [d]p-value for hypertension control differences, [e]economic residential segregation; low, Gi* statistic ≤ − 1; medium, between 1 and − 1; high, ≥ 1

lower maternal education, lower income, and less prestigious occupations and were less likely to have private health insurance and more likely to be obese and to have diabetes and chronic kidney disease. Also, they had poorer health-related behaviors (less physical activity, greater sodium consumption, and current smoking) than White people (Online Resource 2).

Age- and gender-adjusted prevalence of uncontrolled hypertension in the overall sample was highest for Black (54.2%), intermediate for Brown (52.6%), and lowest for White (39.0%) people. Moreover, when looking into economic segregation categories (low, medium, high), uncontrolled hypertension remained higher for Black and Brown participants than for White participants, regardless of the level of economic segregation. Uncontrolled hypertension showed a dose–response pattern with increasing segregation levels for White participants, but not for Black and Brown participants (Fig. 3).

Age- and gender-standardized prevalence difference in uncontrolled hypertension (total disparity) was 16.1% (95% CI 12.2; 19.8) for Black vs White participants and 13.1% (9.2%; 16.9%) for Brown vs White participants. After adjusting for age, gender, education, and study center, residual racial disparity (unexplained portion) in uncontrolled hypertension was 18.2% (13.4%; 22.9%) for Black vs White participants and 12.6% (8.2%; 17.1%) for Brown vs White participants. However, the disparity reduction (explained portion) after equalizing economic segregation across race groups was − 2.1% (− 5.1%; 1.3%) for Black vs White participants and 0.5% (− 1.7%; 2.8%) for Brown vs White participants (Table 2).

Secondary analyses considering only participants with hypertension treated ($N = 3023$) showed quite similar results, although racial inequities were slightly greater, compared to analyses considering all participants with hypertension (Online Resources 3 and 4).

Table 2 Standardized prevalence difference (total disparity), disparity reduction, and disparity residual for uncontrolled hypertension associated with race. ELSA-Brasil (2008–2010), $N = 3897$

	Uncontrolled hypertension ($N = 3897$)[d]		
	Beta[c]	95% CI	
Black vs White participants[a]			
Total disparity, age/gender standardized	**0.161**	**0.122**	**0.198**
Disparity reduction[b]	− 0.021	− 0.051	0.013
Disparity residual[b]	**0.182**	**0.134**	**0.229**
Brown vs White participants[a]			
Total disparity, age/gender standardized	**0.131**	**0.092**	**0.169**
Disparity reduction[b]	0.005	− 0.017	0.028
Disparity residual[b]	**0.126**	**0.082**	**0.171**

[a]Setting White participants as standard; [b]adjusted for age, gender, education, and center; [c]estimates in the risk difference scale; [d]among all participants with hypertension

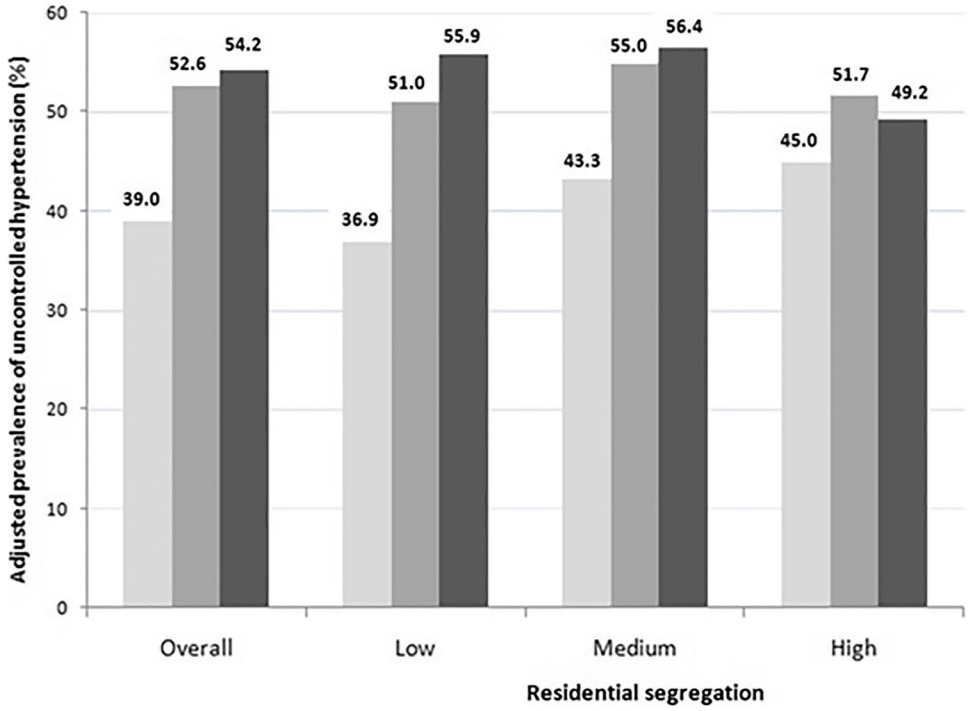

Fig. 3 Age- and gender-adjusted prevalence of uncontrolled hypertension by race and economic residential segregation. ELSA-Brasil (2008–2010), $N = 3897$. Note: economic residential segregation; low, Gi* statistic ≤ − 1; medium, between 1 and − 1; high, ≥ 1

Discussion

In this large multiracial sample of Brazilian adults, we found that the age- and gender-adjusted prevalence of uncontrolled hypertension was higher for Black and Brown people, compared to White people (54.2%, 52.6%, and 39.0%, respectively), supporting our hypothesis of racial inequities in uncontrolled hypertension. After adjustments for age, gender, education, and study center, the residual racial disparity (unexplained portion) in uncontrolled hypertension was 18.2% and 12.6% for Black and Brown people, respectively, versus White people. However, such inequities were not explained by economic segregation. Although uncontrolled hypertension showed a dose–response pattern with increasing segregation levels for White participants, this was not seen for Black and Brown participants. Our findings showed that if we could intervene to eliminate racial disparities in economic segregation (e.g., if Black people had the distribution of economic segregation of White people), uncontrolled hypertension would decrease 2.1% among Black people, although this result was not significant.

Our research demonstrated striking racial inequities in uncontrolled hypertension (more favorable for White people, less favorable for Black and Brown people), regardless of economic segregation. Such inequities might be attributable to racial discrimination and low SES experienced by Black and Brown Brazilians, shaped by structural racism. Due to an existing racial hierarchy and a racist culture that create privileges for White people and barriers for nonwhite people through both interpersonal and institutional mechanisms of discrimination [15, 23], Black and Brown people are less likely than White people to have access to quality health services for prevention, diagnosis, and treatment of hypertension [32]. In addition, Black and Brown Brazilians have, historically, lower SES over the lifecourse, which is expressed through severe racial inequities in education, income, and occupation. In our sample, Black individuals are 7.5-fold less likely to have their mothers with university degree and earn less than 50% than White individuals (Online Resource 2). Both low lifecourse SES and the greater perception of racial discrimination that disproportionately affect Black and Brown people compared to White people are related to higher chronic stress, worse medication adherence, and poorer health-related behaviors [12, 33], leading to racial inequities in hypertension management and control. According to our results, the combined effects of these factors may offset potential gains from higher levels of economic integration among Black and Brown participants. This suggests that any policy strategy to address economic integration must also address these social determinants of health to have meaningful impacts on disparities in hypertension control.

In secondary analyses, we showed that even when looking only at those participants with hypertension treated, Black and Brown participants were less likely than White participants to achieve hypertension control (Online Resource 3). Actually, racial inequities in hypertension control were even greater among those receiving treatment. This could be explained because when selecting only participants with hypertension treated (i.e., those with higher access to healthcare), we restrict the sample for those higher SES individuals (Online Resource 4). Evidence shows that racial discrimination perceived by Black and Brown Brazilians is greater for higher SES, compared to lower SES ones, possibly due to a greater awareness of unfair treatment among the former [8, 34]. Consistent with our findings, recent results from ELSA-Brasil revealed racial inequities in the incidence of obesity to be greater and significant only among higher SES individuals [8].

Economic segregation, a structural manifestation of racism [33, 35], has been considered a fundamental cause of racial health inequities because it shapes the distribution of resources and constraints for racially marginalized groups at both the individual (e.g., by determining less access to educational and employment opportunities) and community levels (e.g., through restricted healthcare access, high densities of fast food outlets, poor walkability) [2, 15, 33]. However, economic segregation did not explain racial inequities in uncontrolled hypertension in our study. Although race differences persist across all economic segregation groups, Black and Brown participants living in the highest segregated neighborhoods did not show the greatest rates of uncontrolled hypertension, in contrast to what we would expect. This could be explained because ELSA-Brasil is a cohort of civil servants and it is known that employment is a form of access to private health insurance in Brazil [36]. In comparison to the Brazilian population, our sample has greater access to healthcare services (e.g., over 78% use antihypertensive medications and 72% are covered by private health insurance vs 42.7% [37] and 27.9% [36] of Brazilian adults, respectively) with a much lower use of the public health sector (Brazil's Unified Health System — SUS), in comparison to the general population, even among Black and Brown participants living in more segregated areas. Moreover, ELSA-Brasil does not include those individuals at the extremes of the Brazilian income distribution (i.e., the richest and the poorest) limiting the range of economic segregation in our sample, potentially affecting the association between race and hypertension control across economic segregation groups.

Previous studies have examined the contribution of neighborhood SES on racial disparities in hypertension control [12, 38] and showed results similar to ours. Morenoff et al. [12] found that the adjustment for residential socioeconomic context (including socioeconomic status, race composition, and age composition) failed to explain Black–White disparities in hypertension control. A recent study by Liu et al. [38],

examining whether neighborhood SES was a mediator of racial disparities in uncontrolled hypertension, showed that neighborhood SES mediated only a small proportion (6.6% between Black and White participants and 7.2% between Hispanic/Latino and White participants) of racial disparities in uncontrolled hypertension. The authors argued that the neighborhood environment is only one of many intersecting potential pathways that may play a role in the inequitable distribution of CVD risk factors among racial groups. Moreover, their study (as well as ours) did not include direct measures of access to transportation or distance from healthcare clinics and pharmacies. Finally, as shown in Fig. 3, lower levels of economic segregation were associated with better hypertension control among White participants but not among Black or Brown participants. The reasons for this are likely complex and ripe for future research; however, one hypothesis may be that additional forces, possibly structural in nature, serve to counteract the protective benefits of economic integration among Black and Brown participants.

Our main limitation is the cross-sectional design, hindering causal conclusions. However, our sample had a mean time of 17 years living in the same neighborhood [39] and thus, cross-sectional economic segregation data might represent past exposure levels. Moreover, ELSA-Brasil is not a population-based study and hence, the highest- and the lowest-income strata individuals are not represented. Although non-analyzed subjects (i.e., those without hypertension) were more likely to be White participants, younger, higher educated, and to live in low segregated neighborhoods (Online Resource 1), there were no racial differences in uncontrolled hypertension by residential segregation groups among them, because they were all participants without hypertension and had their blood pressure controlled. Thus, a selection bias is unlikely to explain our findings. Strengths include the large sample size and detailed assessments of clinical and social data. Furthermore, we used standard clinical guidelines for uncontrolled hypertension definition for those with diabetes or chronic kidney disease, thus accounting for potential confounding due to the higher prevalence of these conditions among Black people [4] (Online Resource 2). Our relatively large sample and use of categorical covariates with few levels made our inferences more robust to the positivity assumption (i.e., the need for race-specific variability within economic segregation strata — low, medium, high) violation.

In conclusion, we demonstrated that uncontrolled hypertension was greater for Brown and greatest for Black people relative to White people, but differences were not explained by economic segregation. Future research might explore why economic integration seems to confer beneficial effects on hypertension control for White people but not for Brown and Black people. To our knowledge, this is the first study that has investigated the explanatory role of economic residential segregation on racial inequities in uncontrolled hypertension. This research extends previous investigations by focusing on a contextual factor, rather than on individual-level factors. Our study reinforces the health gap between Black, Brown, and White people shaped by racial discrimination and structural racism in Brazil. Antiracist policies and culture, which include affirmative actions and greater access to quality healthcare for Black and Brown people, could reduce racial inequities in hypertension control.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s40615-023-01582-w.

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Author Contribution Joanna MN Guimarães drafted the article and conducted the analyses. John W Jackson designed and conducted the analyses. Joanna MN Guimarães, Dora Chor, Sharrelle Barber, and John W Jackson conceived the article and interpreted the data. All authors interpreted the data, revised it critically for important intellectual content, approved the final manuscript, and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Data Availability The data used in this study are available for reasearch proposals upon reasonable request to the ELSA-Brasil's Datacenter (estatisticaelsa@ufrgs.br).

Declarations

Ethics Approval ELSA-Brasil was approved at each of the six study centers by the local Institutional Review Board addressing research in human subjects and also by the National Research Ethics Committee (CONEP). This study was performed in line with the principles of the Declaration of Helsinki.

Consent to Participate Informed consent was obtained from all individual participants included in the study.

Competing Interests The authors declare no competing interests.

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