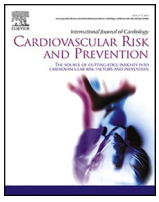
International Journal of Cardiology Cardiovascular Risk and Prevention 25 (2025) 200381

Contents lists available at ScienceDirect

International Journal of Cardiology
Cardiovascular Risk and Prevention

journal homepage: www.journals.elsevier.com/international-journal-of-cardiology-cardiovascular-risk-and-prevention



Associations between racial residential segregation and hypertensive disorders of pregnancy among Black women: The Coronary Artery Risk Development in Young Adults Study

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ARTICLE INFO

Handling Editor: D Levy

Keywords:
Hypertensive disorders of pregnancy
Maternal health
Social determinants of health
Segregation
Health disparities
Racial inequities
Race
Neighborhood
Maternal mortality
Hypertension

ABSTRACT

Introduction: Black women are at greater risk of hypertensive disorders of pregnancy (HDP). Racial residential segregation (RRS) drives racial health disparities. This study investigates the association between RRS and the onset of HDP among Black parous women in the U.S.

Methods: The Coronary Artery Risk Development in Young Adults study is a cohort of Black and White adults aged 18–30 from four U.S. cities, recruited in 1985 and followed for over 30 years. RRS was measured using the local Getis-Ord Gi* statistic, categorizing neighborhoods as high (Gi* >1.96), medium (Gi* 0–1.96), or low (Gi* <0). Among Black women with at least one post-baseline pregnancy, HDP was self-reported as gestational hypertension, preeclampsia, or eclampsia. Generalized mixed models determined the association between RRS and HDP, for pregnancies (n = 941) nested within Black women (n = 598), and adjusting for age, follow-up time, time to pregnancy, education, income, BMI, physical activity, smoking, hypertension, baseline parity, and cumulative pregnancies.

Results: The mean age was 23.1 years (SD: 3.6), with 22.7 % reporting HDP in at least one pregnancy. The cumulative incidence of HDP was 23.0 % in high, 20.6 % in medium, and 23.7 % in low RRS neighborhoods. Fully adjusted models showed no significant association between medium RRS (OR: 1.11; [95 % CI: 0.52, 2.40]) or low RRS (OR: 0.94; [95 % CI: 0.42, 2.16]) compared with high RRS and HDP.

Conclusions: RRS was not associated with HDP among Black women. Future research should consider multifaceted factors through which racial segregation may relate to maternal outcomes.

1. Introduction

Hypertensive disorders of pregnancy (HDP) such as gestational hypertension, preeclampsia, eclampsia, and chronic hypertension with superimposed preeclampsia are major contributors to maternal morbidity and mortality [1]. HDP have been on the rise, increasing from 13.3 % to 15.9 % among delivery hospitalizations in the US [2], with Black women disproportionately affected [3,4]. Despite advances in reproductive health care, racial and ethnic disparities in maternal morbidity and mortality persist, with risk of maternal mortality 3.5-fold higher for Black women [5,6].

Multiple neighborhood-level factors and the built environment are associated with poor maternal health behaviors, pre-pregnancy chronic disease and adverse pregnancy outcomes [7], including HDP [8]. Racial residential segregation (RRS) has been identified as a fundamental cause of racial disparities in health [9]. In particular, RRS, a product of

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https://doi.org/10.1016/j.ijcrp.2025.200381
Received 16 October 2024; Received in revised form 12 January 2025; Accepted 5 March 2025
Available online 6 March 2025

structural racism [10,11], is a primary cause of socioeconomic inequity between Black and White adults as it determines access to education and employment opportunities [12], both of which operate upstream of health outcomes. RRS systematically shapes health [9], as it influences health-care access, utilization, and quality across multiple levels of social influence [11]. For example, Black women living in segregated communities face barriers to optimal health such as: cost, transportation, childcare, psychological distress, communication with providers, and health literacy [13,14]. Research from the Coronary Artery Risk Development in Young Adults (CARDIA) study shows that neighborhood-level RRS is associated with poor cognitive functioning [15], cardiovascular disease [7,16], and chronic hypertension [17] - a major HDP risk factor [18]. A recent study also showed HDP as a partial mediator of racial and ethnic disparities in severe maternal morbidity [19]. To date, studies relating RRS with HDP are sparse and limited [20–22]. To our knowledge, only two prior studies have examined the direct association between RRS and HDP in the US - one cross-sectional study limited to Chicago [20], and one longitudinal study limited to California [22]. The objective of this study is to examine the longitudinal association between RRS and HDP, specifically in Black women across 4 US cities.

2. Methods

2.1. Study population

CARDIA is an on-going prospective cohort study of 5115 Black and White US adults (nBlackWomen = 1480; nWhiteWomen = 1307) designed to assess the determinants of cardiovascular disease (CVD) and its risk factors. Participants were aged 18–30 when they were recruited in 1985 from four field centers in Birmingham, AL; Minneapolis, MN; Chicago, IL; and Oakland, CA, and to date followed over nine exams through 2020. Participants were selected with similar sample sizes in subgroups of sex, age, race, and education across centers. Participants were granted informed consent before entering the study and at every follow-up visit; one participant withdrew consent and was not included. Standardized protocols were used to gather demographic, socioeconomic, and clinical data, including pregnancy information [23].

As in other studies, we included only Black women due to their unique experience of segregation in the US [15,17]. Pregnancies occurring after the 1985 baseline were included to establish temporality between exposure and HDP outcome. Only pregnancies that reached a gestational age of more than 23 weeks and did not result in miscarriage, ectopic (tubal) pregnancy, or abortion were included. For this study, pregnancies are defined as those resulting in either a live birth (n = 917) or stillbirth (n = 24); pregnancies with missing data (n = 60) were assumed to be a live birth. Each reported pregnancy between exams was treated as a single observation. We analyzed pregnancies reported from exam year 2 (1987–1988) onward [24]. Out of 2787 CARDIA participants, 1480 were Black women, 660 of whom reported at least one pregnancy post-baseline. Our final sample consisted of 941 pregnancies nested within 598 Black parous women with no baseline HDP history, reporting HDP data over 30 years of follow-up (1985–2015).

2.1.1. Neighborhood-level racial residential segregation (RRS)

RRS was measured using the local Getis-Ord Gi* statistic, [19,34] which compares the racial composition of a neighborhood to its larger metropolitan area. The Gi* statistic for Black racial composition was calculated by linking CARDIA participants' geocoded addresses to tract-level census data at 6 CARDIA visits (1985–1986, 1992–1993, 1995–1996, 2000–2001, 2005–2006, and 2010–2011). This statistic accounts for the proportion of Black residents in a census tract relative to the surrounding metropolitan area, producing a z-score indicating the difference in racial composition. Segregation was categorized as high (Gi* >1.96), medium (Gi* 0–1.96), or low (Gi* <0), with high segregation as the reference. To establish temporality, outcome and confounder measurements were lagged from the exposure. For example, the segregation score from 1985 (Y0) was used as an independent variable for HDP reported in 1987 (Y2). Detailed calculation methods are in the supplemental section by Kershaw et al. [19].

2.1.2. Hypertensive disorders of pregnancy

HDP was assessed in the pregnancy questionnaire asked in all years of the CARDIA study: *"Since last exam, did you have any of these illnesses or complications during this pregnancy: a. toxemia, including all of the following: high blood pressure, albumin in urine and swelling of the ankle? b. high blood pressure without toxemia?"* An affirmative response to either question was considered HDP (binary outcome). Women with chronic hypertension who reported 'yes' to question a. were also considered as having HDP as chronic hypertension with superimposed preeclampsia is a sub-type of HDP. However, women who reported GH but also had a diagnosis of chronic hypertension prior to pregnancy were excluded (n = 4). This is because GH is defined as hypertension occurring after 20 weeks of gestation [1], and including these four women with pre-existing hypertension would have resulted in a misclassification of GH.

2.1.3. Covariates

Race, sex, years of education completed, household income, age at pregnancy, prior pregnancies, prior HDP, and smoking status (never, current, or former smokers) were obtained via questionnaire at each study year. Participants also self-reported their physical activity in exercise units using the validated CARDIA Physical Activity History questionnaire [25], which includes 13 specific categories of recreational sports, exercise, leisure, and occupational physical activity in the past 12 months. Physical activity was reported in exercise units (EU). A score of 300 EU is roughly equivalent to meeting national physical activity guidelines of ≥150 min per week i.e. 2 EU for every 1 min [26,27]. Body mass index (BMI, kg/m^2) was assessed using measured height (m^2) and weight (kg). Systolic and diastolic blood pressure (SBP and DBP, mmHg) was recorded and standardized as the average of three measurements, taken with a 1-min rest period in between measurements. To adhere to the clinical standard at the time of the study (1985–2015), hypertension was assessed as a categorical variable according to Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC7) guidelines [28] and self-reported blood pressure medication use at the exam year prior to the reported pregnancy: *normal*: SBP<120/DBP<80 mmHg, no reported blood pressure medications; *prehypertension*: 120≤SBP<140/80≤DBP<90 mmHg, no reported blood pressure medications; *hypertension*: self-reported use of blood pressure medications or SBP≥140/DBP≥90 mmHg. Follow-up time from baseline to exam date when pregnancy was reported, as well as time from baseline to date of delivery. Parity at baseline was based on self-report from the CARDIA pregnancy questionnaire item "*how many times have you been pregnant*?" at exam Y0. Parity here is defined as any pregnancy regardless of the pregnancy outcome. All time-varying covariates, similar to RRS, were assessed at the exam year immediately preceding pregnancy.

2.2. Statistical analysis

Among the 598 Black women having at least one post-baseline pregnancy, we described demographic, socioeconomic, and clinical characteristics overall and according to self-reported HDP throughout the study period. Next, we estimated cumulative incidence of ever reporting HDP overall and according to RRS tertile at baseline.

To examine the relationship between RRS and HDP, we treated pregnancies as the unit of analysis (e.g., a woman with two pregnancies contributed two observations) using repeated measures analysis to account for clustering amongst women. We used two approaches to quantify the association between RRS and HDP. In the first approach, we used a structural equation modeling (SEM) framework to conceptualize

the unadjusted association between RRS (modeled as a continuous variable) and each pregnancy over time. This approach is beneficial as it allows for the examination of multiple pathways in one model. For this SEM, we utilized a unidirectional, unadjusted, lagged model for each pregnancy, up to the 4th pregnancy. We predicted future HDP from prior HDP and predicted future RRS from prior RRS. We depicted this model graphically, displaying odds ratios and corresponding 95 % confidence intervals (CI).

In our second approach, we used adjusted generalized linear mixed models with a binomial distribution and a logit link function to determine whether RRS was associated with incident HDP. This is important to account for repeated measures (pregnancies) overtime. For these models, we tested whether the use of a 3-level hierarchical model was necessary to account for multiple levels of clustering (pregnancies nested within women, nested within neighborhoods). Analyses showed that there was no significant residual impact of nesting at the neighborhood-level (intraclass correlation coefficient~0.00), therefore we utilized two-level models (pregnancies nested within women). RRS was modeled both in SD decrements, and as a categorical variable (RRS tertiles). We included both fixed and time-varying covariates in all models. Model 1 was adjusted for age, time to pregnancy, and follow-up time from baseline. Model 2 included model 1 adjustments in addition to time-varying income and education. Model 3 included all model 2 adjustments in addition to fixed parity at baseline, cumulative pregnancies during study and the following time-varying factors: BMI, physical activity, smoking, and hypertension status all prior to pregnancy.

Significance was determined at two-tailed $\alpha = 0.05$. Analyses were conducted using SAS Version 9.4 and MPLUS Version 8 Software.

3. Results

Among 598 Black women enrolled in the CARDIA study with at least one post-baseline pregnancy, 239 women had a second, 75 women had a third, 15 women had a fourth, 9 women had a fifth, 2 women had a sixth, 1 woman had a seventh, eighth and ninth, totaling 941 pregnancies over the course of the study.

Table 1 shows characteristics of our study sample at baseline, prior to pregnancies occurring during the study (1985–2015). The women who eventually developed HDP and those who did not had comparable average ages at baseline. Most participants had an annual household income of less than $35,000, with similar income distributions by HDP. Overall, 18.2 % of all participants had greater than high school education and 16.6 % were married at baseline. Forty-two percent of women were nulliparous at baseline and 30.6 % had two or more pregnancies at baseline. The mean BMI for the overall sample was 24.5 kg/m^2 (SE: 5.5) and the average physical activity at baseline was 295.9 exercise units (EU) (SE: 231.2). Women who developed HDP were less likely (χ^2-test p-value <0.05) to be married and less likely to have had 2 or more pregnancies at baseline. There was no difference among women who did and did not develop HDP in BMI, hypertension, diabetes, high cholesterol, smoking and physical activity at baseline.

Among Black parous women, 22.7 % developed HDP in at least one pregnancy during the CARDIA study, Fig. 1. The cumulative incidence of HDP did not differ by baseline RRS tertiles ($p = 0.90$); the cumulative incidence of HDP was 23.0 % among women in high RRS neighborhoods, 20.6 % among women in medium RRS neighborhoods, and 23.7 % among women in low RRS neighborhoods.

The unadjusted association between RRS and HDP at each pregnancy is depicted in Fig. 2. The association between RRS and HDP was not significant in pregnancy 1 through pregnancy 4. HDP in pregnancy 1 significantly predicted HDP in pregnancy 2 ($p < 0.01$), but HDP in pregnancy 2 and 3 did not predict HDP in future pregnancies, likely due to small sample sizes in these groups. All autoregressive terms for RRS significantly predicted RRS scores at the following visit ($p < 0.01$).

Multivariable adjusted 2-level generalized linear mixed model results accounting for random intercepts at the individual subject level, are displayed in Table 2. The association between continuous RRS score and HDP was not statistically significant in minimally adjusted models (model 1 OR: 1.06; [95%CI: 0.97, 1.15]), or fully adjusted models (model 3 OR: 1.02; [95 % CI: 0.94, 1.12]). When modeled as a categorical variable, compared with high RRS, medium RRS (OR: 1.26; [95 % CI: 0.59, 2.70]) and low RRS (OR: 0.79; [95 % CI: 0.34, 1.83]) were not associated with HDP in minimally adjusted model 1. Likewise in fully adjusted model 3, compared with high RRS, medium RRS (OR: 1.11; [95 % CI: 0.52, 2.40]) and low RRS (OR: 0.94; [95 % CI: 0.42, 2.16]) were not associated with HDP. Sensitivity analyses in Table 3, restricted to women without hypertension prior to reported pregnancy produced similar results showing no significant association between RRS and HDP. The association between RRS, (as a continuous and categorical variable) with HDP remained non-significant in fully adjusted models stratified according to parity at baseline, Table 4.

Table 1
Baseline Characteristics among parous Black women (n = 598), stratified by the cumulative incidence of HDP during CARDIA study 1985–2015.

Characteristic	Parous Black Women			χ^2 test p-value
	All (n = 598)	Ever HDP (n = 136)	No HDP (n = 462)	
	N (%)	N (%)	N (%)	
Mean Age (SD): 17–31	23.1 (3.6)	23.2 (3.7)	23.1 (3.5)	0.677
Family Income[a]				
<$16,000	178 (29.8)	43 (31.6)	135 (29.2)	0.377
<$25,000	90 (15.1)	24 (17.7)	66 (14.3)	
<$35,000	86 (14.4)	15 (11.0)	71 (15.4)	
<$50,000	76 (12.7)	13 (9.6)	63 (13.6)	
<$75,000	61 (10.2)	17 (12.5)	44 (9.5)	
≥$75,000	21 (3.5)	7 (5.2)	14 (3.0)	
Missing	86 (14.4)	17 (12.5)	69 (14.9)	
Greater than HS education	109 (18.2)	22 (16.2)	87 (18.8)	0.756
Married	99 (16.6)	14 (10.3)	85 (18.4)	0.010
Parity				
0	252 (42.1)	60 (44.1)	192 (41.6)	0.001
1	163 (27.3)	50 (36.8)	113 (24.5)	
2+	183 (30.6)	26 (19.1)	157 (34.0)	
Mean BMI (SD)	24.5 (5.5)	25.4 (5.9)	24.3 (5.4)	0.051
Blood pressure				
Normal	523 (87.5)	112 (82.4)	411 (89.0)	0.064
Pre-hypertension	64 (10.7)	19 (14.0)	45 (9.7)	
Hypertension	11 (1.8)	5 (3.7)	6 (1.3)	
Diabetes	5 (0.8)	2 (1.5)	3 (0.7)	0.631
High cholesterol	7 (1.2)	0 (0.0)	7 (1.5)	0.255
Current Smoker	166 (27.8)	39 (28.7)	127 (27.5)	0.867
Mean Physical Activity Intensity	296.0 (231.2)	309.3 (240.3)	292.1 (228.6)	0.447

Abbreviations: CARDIA: Coronary Artery Risk Development in Young Adults; HDP: Hypertensive Disorders of Pregnancy; HS: High School; BMI: Body Mass Index; HTN: Hypertension; SD: Standard Deviation.
[a] Income based on year 5 (1990), not at baseline.

4. Discussion

In a study of 598 Black women living in 4 communities across the US, 22.7 % reported HDP in at least one pregnancy post-baseline. While the association between RRS and cardiometabolic health factors, such as obesity [29], CVD [7,16] and elevated blood pressure [17], provides a link that segregation increases the risk of HDP [18], in the current study we did not find that RRS was directly associated with HDP. Future studies with larger samples may be necessary to detect associations.

Our null findings align with a prior Chicago study of Black parous women, which found no significant association between racial residential segregation RRS and HDP [20]. Mayne et al. also reported no association between RRS and HDP after adjusting for neighborhood

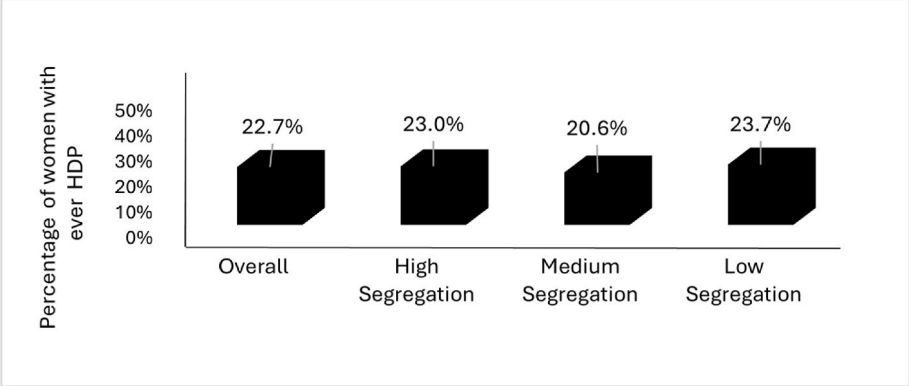

Fig. 1. Cumulative incidence of HDP among parous Black women (n = 598), overall and by baseline racial residential segregation tertile, CARDIA study.
Abbreviations: CARDIA: Coronary Artery Risk Development in Young Adults; HDP: Hypertensive Disorders of Pregnancy.

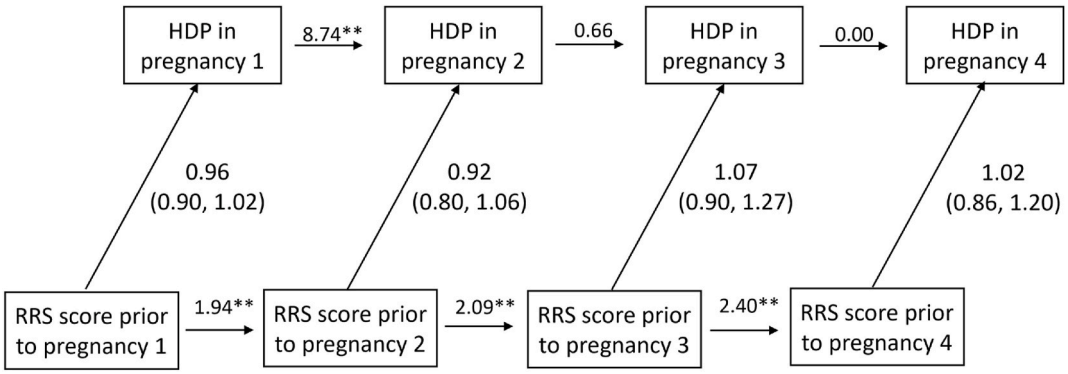

Fig. 2. Structural equation model depicting the association between RRS and HDP up to fourth pregnancy.
**p < 0.01.
Abbreviations: CARDIA: Coronary Artery Risk Development in Young Adults; HDP: Hypertensive Disorders of Pregnancy; RRS: Racial Residential Segregation.
Notes: History of HDP and RRS were related to future HDP and RRS respectively. There was no significant association between RRS and HDP.

Table 2
Association between RRS with HDP among parous Black women, CARDIA study 1985–2015 (n = 941 pregnancies).

	Model 1	Model 2	Model 3
Per 1 SD decrement (95 % CI)	1.06 (0.97,1.15)	1.03 (0.94, 1.12)	1.02 (0.94,1.12)
RRS Category			
High	1.00	1.00	1.00
Medium	1.26 (0.59, 2.70)	1.11 (0.52, 2.36)	1.11 (0.52, 2.40)
Low	0.79 (0.34, 1.83)	0.92 (0.41, 2.09)	0.94 (0.42, 2.16)

Abbreviations: CARDIA: Coronary Artery Risk Development in Young Adults; RRS: racial residential segregation; HDP: Hypertensive Disorders of Pregnancy; SD: Standard Deviation.
Model 1 adjusted for age, follow-up time, time to pregnancy.
Model 2: Model 1 + education, income.
Model 3: Model 2 + BMI, physical activity, smoking, hypertension, parity at baseline, number of post-baseline pregnancies.

Table 3
Sensitivity analysis removing all observations with hypertension prior to pregnancy (n = 910 pregnancies).

	Model 1	Model 2	Model 3
Per 1 SD decrement (95 % CI)	1.05 (0.96,1.15)	1.03 (0.94,1.12)	1.03 (0.94,1.12)
RRS Category			
High	1.00	1.00	1.00
Medium	1.17 (0.52, 2.61)	1.12 (0.51, 2.44)	1.11 (0.50, 2.46)
Low	0.70 (0.28, 1.71)	0.88 (0.38, 2.07)	0.91 (0.39, 2.14)

Model 1 adjusted for age, follow-up time, time to pregnancy.
Model 2: Model 1 + education, income.
Model 3: Model 2 + BMI, physical activity, smoking, elevated BP, parity at baseline, number of post-baseline pregnancies.
Abbreviations: RRS: Racial Residential Segregation; SD: Standard Deviation.

poverty and maternal characteristics [20]. However, in neighborhoods where poverty rates exceeded 20 %, women in highly segregated areas had higher odds of experiencing HDP [20]. Additionally, another study showed that women in predominantly (≥75 %) Black neighborhoods had infants with lower body weight, but this association became non-significant after adjusting for delivery age, parity, neighborhood deprivation, and socioeconomic position throughout life [30].

Community factors, economic inequalities, and individual CVD risk are pathways through which segregation influences health. RRS is a major contributor to racial differences in income, education, and employment [9]. This racialized economic segregation is associated with high allostatic load from chronic stressors related to socio-economic disparities and limited access to resources [31]. A recent study found that high allostatic load in the first trimester correlates with adverse pregnancy outcomes, especially HDP, with the association varying by race [32]. Additionally, interpersonal discrimination in segregated environments further exacerbates stress and contributes to poor cardiovascular health, increasing the risk of HDP [33]. While, a

Table 4
Association between Racial Residential Segregation with incidence of Hypertensive Disorders of Pregnancy, stratified by parity at baseline in fully adjusted model 3, (n = 941 pregnancies).

Model 3 (Fully Adjusted)	Parity at baseline		
	0	1	2+
Per 1 SD decrement (95 % CI)	1.02 (0.89,1.17)	1.07 (0.90,1.27)	1.01 (0.85,1.21)
RRS Category			
High	1.00	1.00	1.00
Medium	0.95 (0.32, 2.87)	2.04 (0.49, 8.62)	0.98 (0.13, 7.65)
Low	0.80 (0.23, 2.78)	1.40 (0.31, 6.40)	0.94 (0.14, 6.20)

Brazilian Longitudinal Study by Guimarães et al. found that racial inequities in uncontrolled hypertension were not explained by economic segregation [34], another study on neighborhood racialized economic segregation among Black women revealed a clear stepwise gradient in the likelihood of experiencing HDP [22]. Specifically, the risk of HDP increased progressively as the economic conditions of their adult neighborhoods worsened for women who grew up in mixed or privileged neighborhoods [22]. However, this gradient was not observed among women who had lived in deprived neighborhoods during childhood; for these women, the risk of HDP remained consistent, regardless of the socioeconomic status of their adult neighborhood [22]. This suggests that Black women raised in deprived neighborhoods may not experience the health benefits often associated with upward social mobility. Our findings, in conjunction with this study, highlight that while RRS may indirectly impact health outcomes, the high incidence of HDP among Black women is driven by a complex interplay of socioeconomic, genetic, environmental, behavioral, and healthcare-related factors [34]. Chronic challenges facing Black communities—such as poverty, high-stress occupations or unemployment, limited access to prenatal care, and health behaviors—likely contribute to this disparity in HDP risk.

Further, racial segregation is complex and has been described to result in both protective and harmful effects. For example, while segregation particularly in Black communities, is associated with increased exposure to air pollutants, decreased longevity, increased risk of chronic disease, and increased crime rates [35], it has also been linked to positive outcomes such as African-American empowerment, strong social networks, and community cohesion [36]. Studies on marginalized and immigrant populations emphasize the protective role of close social connections and reduced exposure to racial discrimination in racially homogenous environments [37]. A supportive neighborhood with strong social ties and a sense of security can alleviate chronic stressors [38], buffer the health effects of discrimination and systemic racism [39], and provide greater access to community resources [40]. This intricate interplay of psychosocial and healthcare-related factors underscores the numerous harmful or protective mechanisms through which racial segregation could impact maternal outcomes.

This study is not without limitations. First, we did not characterize HDP into its various subtypes as self-reported HDP and sub-types are often inaccurate,[41] particularly in CARDIA [24], and would likely result in inadequate power to detect associations. We acknowledge that future studies would benefit from using verified HDP cases based on clinical records. Another limitation is the exclusion of pregnancies resulting in miscarriages, tubal pregnancies and abortions as we understand we could have excluded the severe cases of HDP. However, this is unlikely as these tend to occur within the first 13 weeks of gestation, whereas HDPs usually develop after 20 weeks gestation [1]. Additionally, neighborhood segregation data were not available for all study years. To address this, we extrapolated segregation values from the most proximal available year (e.g. Y0 was used for Y2 and Y7 was used for Y5). This could have resulted in imprecision, contributing to our null findings. Further, we were unable to elucidate whether women received prenatal care within their neighborhoods or elsewhere, as this could have had an impact on healthcare resources, the quality of the prenatal care, and patient education and outreach, all of which influence maternal outcomes like HDP. Another limitation of neighborhood research is that we could not account for routine movement in and out of a neighborhood (e.g. dose of exposure), as we did not have information on time spent in the neighborhood. Despite these challenges, this study has notable strengths. The data source encompasses a recent timeframe with Black women of child-bearing age, an underrepresented population in research. We also extend research looking at the association with RRS and HDP to four national locations and make use of longitudinal data to examine incident HDP.

In a large study of Black women followed over 30 years, RRS was not associated HDP. Future research in this area should carefully consider multifaceted factors using objectively measured HDP to elucidate this relationship. This work emphasizes the importance of not only focusing on a single risk factor, but also considering the broader social determinants of health that can influence pregnancy-related complications.

CRediT authorship contribution statement

Leah V. Dodds: Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Daniel J. Feaster:** Writing – review & editing, Supervision, Methodology, Formal analysis. **Kiarri N. Kershaw:** Writing – review & editing. **Erica P. Gunderson:** Writing – review & editing. **Tatjana Rundek:** Writing – review & editing, Conceptualization. **Michael Paidas:** Writing – review & editing. **Tali Elfassy:** Writing – review & editing, Validation, Supervision, Software, Project administration, Investigation, Formal analysis, Data curation, Conceptualization.

Consent to participate

Informed consent was obtained from all individual participants included in the CARDIA study at every follow-up visit.

Availability of data and material

CARDIA data are available for use upon request. Any investigator can request data following the submission of a manuscript proposal laid out on the study website: https://www.cardia.dopm.uab.edu/publications-2/manuscript-proposal-form.

Code availability

The code is readily available to investigators upon reasonable request.

Ethics approval

This is an observational study. Institutional review boards at each of the participating CARDIA sites approved the human subjects' protocol at each examination. The University of Miami Institutional Review Board Research Ethics Committee has confirmed that no ethical approval is required. (IRB# 20220289).

Consent for publication

This manuscript was reviewed by the CARDIA Publications & Presentations committee who granted consent to submit this paper for publishing.

Funding

The Coronary Artery Risk Development in Young Adults Study (CARDIA) is conducted and supported by the National Heart, Lung, and Blood Institute (NHLBI) in collaboration with the University of Alabama at Birmingham (75N92023D00002 & 75N92023D00005), Northwestern University (75N92023D00004), University of Minnesota (75N92023D00006), and Kaiser Foundation Research Institute (75N92023D00003). This manuscript has been reviewed by CARDIA for scientific content. Derived pregnancy variables data were supported by R01 DK106201 (Gunderson, PI), R01 DK090047 (Gunderson, PI) from the National Institute of Diabetes, Digestive and Kidney Diseases. Leah V. Dodds is currently supported by NIH/NHLBI (F31 HL165894-01A1). Tali Elfassy was supported by NIH/NIMHD (K01MD014158).

Declaration of competing interests

The authors have no relevant financial or non-financial interests to disclose.

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