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Systematic Review of Chronic Discrimination and Changes in Biology During Pregnancy Among African American Women

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Abstract

Profound racial health disparities in maternal and infant health exist in the USA. Discrimination based on race may contribute to these disparities, but the biological pathways through which racial discrimination acts on health are not fully known. Even less is known about these pathways during development. Examining how racial discrimination becomes biology is paramount because it may shed light on how and when such social forces result in lasting biological consequences for health and wellbeing. To begin exploring this issue, we performed a systematic review of the relationships between experiences of chronic racial discrimination and relevant biomarkers measured during pregnancy among African American women. The literature search included studies published prior to August 2018 in the MEDLINE, Embase, and PsycINFO databases, and 11 studies met our inclusion criteria. We evaluated the articles based on the biological system that the authors investigated, which included the immune, neuroendocrine, and cardiovascular systems. We found that the current literature provides preliminary evidence that experiences of chronic racial discrimination are associated with changes in maternal biology during pregnancy. However, the literature was limited in both quantity and quality. We found only 11 studies that addressed this subject, four of which only provided indirect evidence, and many studies had small sample sizes. Future work in this area should develop more informative methods that consider the interaction between interpersonal and structural racial discrimination, individual variation, and sociocultural factors. We conclude researchers should continue to work in this area and focus on developing more effective study designs and larger sample sizes.

Keywords Racial discrimination · Maternal health · Pregnancy outcomes

Introduction

Pronounced maternal health disparities consistently appear across racial and ethnic divides in the USA, particularly when considering African American maternal health. While the overall prevalence of adverse birth outcomes has decreased in recent decades, the disparity between African American and white infant mortality actually increased from 2015 to 2017 [1]. African American women are 49% more likely to experience a premature labor than all other women and two times as likely to experience gestational hypertension [2, 3]. Additionally, infant mortality is more than two times greater for African American infants than white infants, and maternal mortality is more than three times greater for African American women than white women [4]. These statistics highlight some of the profound health disparities that exist for African American mothers and infants in the USA, and much current research is attempting to identify the root causes of these disparities.

Race, although not a biological category, affects an individual's lived experience, which then leads to biological manifestations [5]. While some have claimed the marked racial health disparities in the USA are driven by genetic differences [see 6], many studies have found that African-born infants and infants of foreign-born US mothers have birth weights similar to US-born white infants and significantly greater than that of African American infants [7–12]. A study by Collins et al. (2002) compared the birth weights of infants of US-born and foreign-born Black and white mothers and tracked changes in average birth weight over three generations. This study found that the initial similarity in birth weights between the children

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of foreign-born women and the infants of US white women persisted among foreign-born white women, but the birth weight of infants of foreign-born Black women decreased over the three generations, approaching the average birth weight of US-born African American infants [13]. Since gene frequencies cannot change that rapidly, these studies suggest that it is not genetics that leads to birth weight disparities but other factors, such as different social conditions in the USA, that contribute to the higher incidence of low birth weight and other adverse pregnancy outcomes.

Social and economic factors, such as socioeconomic status (SES) and education, account for some of the variation in pregnancy outcomes, but racial disparities in maternal and infant health persist even after accounting for these risk factors [11, 14]. Prior research indicates that chronic experiences of discrimination may also contribute to health disparities in birth outcomes. Researchers have found several pathways in which racial discrimination "gets under the skin" to impact health, such as cardiovascular and mental health [15–17]. While several studies have found a relationship between chronic experiences of racism and adverse pregnancy outcomes [18, 19 see 20], relatively little research has looked at the impacts of chronic racism on the biology of African American women during pregnancy itself. Despite the robust associations between chronic discrimination and maternal and infant health, the exact biological pathways that lead to these adverse health outcomes are still unknown. Figure 1 provides a conceptual diagram of how discrimination and health outcomes may be linked by specific biological systems. Understanding these pathways may help to determine how much of racial health disparities are due to the lived experience of chronic discrimination as opposed to other factors, such as disparities in health care settings [21], that may also contribute to racial disparities in maternal and infant health.

Examining the biological pathways through which health disparities manifest during pregnancy is a critical issue as it will impact not only the mother but also the current and future health of her child. First proposed by Barker and colleagues [22–24], the concept that early-life environmental conditions can influence developing biological systems with long-lasting implications for health is now known as the Developmental Origins of Health and Disease Hypothesis. Stressors experienced during pregnancy, such as chronic discrimination, may alter maternal physiology across various systems, changing cardiovascular, neuroendocrine, and inflammatory activities in ways that perturb fetal development [25–27]. For example, in the cardiovascular system, high blood pressure during pregnancy can impact the health of the infant at birth by leading to premature birth and low birth weight. There are also long-term health effects of high blood pressure in pregnancy: infants born to mothers with preeclampsia have elevated blood pressure, body mass index, increased triglycerides, and high cholesterol in both adolescence and adulthood [28, 29]. In the neuroendocrine system, glucocorticoid levels increase during pregnancy and are important for fetal growth and maturation. However, excess glucocorticoid exposure in utero is associated with negative outcomes during development [30–32] as well as greater risk of hypertension, diabetes, and stroke during adulthood [33, 34]. The immune system also changes during pregnancy to prevent the rejection of the fetus by the immune system as a foreign tissue. However, greater inflammation during pregnancy may adversely impact cognitive development and increase risk of neuropsychiatric disorders later in life [35–37]. These are just a few examples of the many ways that maternal health during pregnancy can influence developmental programming to impact an infant's long-term health, perhaps even affecting the infant's own future pregnancy and child through epigenetic changes [38–40].

Racial discrimination—a chronic stressor often defined as differential actions toward others according to their race [41]—may induce epigenetic changes that could both contribute to racial health disparities and be passed from generation to generation [38, 42]. However, to our knowledge, only two studies have looked at DNA methylation and racial discrimination [43, 44]. Given the current dearth of literature on epigenetic changes and chronic discrimination, this review focused on studies that both measure biomarkers taken during pregnancy and evaluate exposure to chronic discrimination to investigate if experiences of chronic discrimination are associated with biologically meaningful changes during pregnancy.

Little research has attempted to investigate the relationship between specific biological changes in pregnancy and racism or discrimination in the USA, a country with marked racial health disparities. The goal of this systematic review was to analyze the literature on studies that both measured biomarkers during pregnancy and evaluated exposure to chronic experiences of discrimination among African American

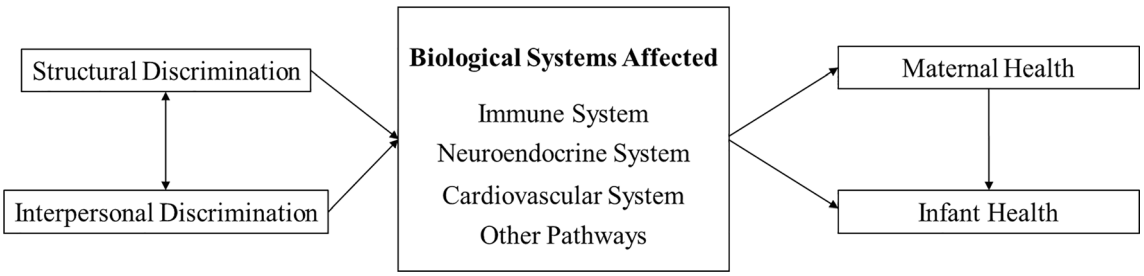

Fig. 1 Conceptual diagram of the relationship between chronic discrimination and health

women. Our aims were to (1) identify all articles that connect chronic racial discrimination, maternal biomarkers during pregnancy, and infant outcomes; (2) identify all articles that investigate only the connection between chronic racial discrimination and biomarkers during pregnancy; (3) determine which biological systems, if any, have robust evidence supporting an association between chronic racial discrimination, biomarkers during pregnancy, and infant outcomes; and (4) based upon the current state of the literature, suggest what future research in this topic would be needed. Ultimately, this review seeks to elucidate the complex links between exposure to racial discrimination, biomarkers examined during pregnancy, and infant outcomes.

Methods

We conducted a systematic search of the MEDLINE, Embase, and PsycINFO databases via the Ovid platform through January 30, 2018, to retrieve articles on the biological impacts of chronic racism as measured during pregnancy. The search was slightly modified in each database to utilize their specific controlled vocabularies, such as MeSH and EMTREE. In addition to the database searching, reference lists of known articles were searched. Altogether, we found 748 potentially relevant articles, which was reduced to 597 after excluding duplicates. The search was repeated in August 2018 using the same search strategy and databases as the first search (MEDLINE, Embase, and PsycINFO) to include more recently published articles. The second search resulted in 55 new articles to be screened after deduplication. One additional article was found that met the inclusion/exclusion criteria for the project. The search strategy consisted both of controlled vocabulary terms and keywords. To construct the search strategy (available in the Supplementary Material), a list of physiological changes during pregnancy was assembled, including broad categories such as inflammation, immune system phenomena, and physiological processes, as well as more specific terms such as oxytocin, insulin secretion, and angiotensin to ensure all possible physiological changes would be included in the search. We then searched for articles that mentioned at least one of the physiological changes, our target population (African American women), and a measure of racial discrimination. Figure 2 highlights the steps of this literature synthesis process.

Articles were included if the following criteria were met: (1) the study population was African Americans, due to limited published research on other populations; (2) the study population was from the USA, as specific experiences of racism vary culturally; (3) the study included a measure of chronic exposure to racism (e.g., not just experiences of discrimination during pregnancy); (4) the study included a biomarker measured during pregnancy. The studies had to be published in English and there was no limit on publication year.

Two independent reviewers screened potentially relevant titles and abstracts. These two reviewers also performed full-text screening, evaluating articles for satisfaction of the inclusion criteria. Disagreements during the title/abstract phase and the full-text phase were resolved by consensus between the two reviewers.

Results

The final list of selected articles included 12 studies that investigated experiences of chronic racism and biomarkers measured during pregnancy, although only two of these studies met the full criteria of additionally investigating the relationship of chronic racial discrimination and biomarkers to infant outcomes. Additionally, one abstract by Christian et al. (2012) [45] appeared to contain the same data and interpretation as the research article Christian et al. (2012) [46], so we only included discussion of the Christian et al. (2012) [46] full article in this review. Thus, the number of included studies was 11. All included studies are listed in Table 1 along with the summary study characteristics of each article.

We found only three studies that addressed our first aim of investigating the relationship between experiences of racial discrimination, biomarkers measured during pregnancy, and infant outcomes [47–49]. Only one of these studies directly investigated the relationship between exposure, outcome, and potential biological mechanisms [48]. All three studies focused on cardiovascular biomarkers as predictors of adverse birth outcomes. Hilmert et al. (2014) found that indirect childhood and direct childhood racism interacted with diastolic blood pressure (DBP) to statistically significantly predict low birth weight risk [48]. However, Grobman et al. (2018) did not find that disparities in hypertensive disease or pregnancy outcomes between African American and white participants were explained by differences in self-reported psychosocial factors, including racial discrimination [47]. The third study, Thayer et al. (2015), found that both pregnant and nonpregnant African American women demonstrated impaired vasodilation related to racial discrimination, and the infants of African American women had significantly lower birth weights compared with those of white women. However, they did not investigate whether birth weight was associated with either racial discrimination or differences in vasodilation [49]. With only three studies investigating the relationship between experiences of racial discrimination, a biomarker measured during pregnancy, and infant outcomes, we did not find sufficient literature to make any conclusions about the relationship between these variables, particularly, since two of the articles did not directly investigate the relationship among our variables of interest. The remaining eight articles addressed our second aim of investigating the relationship between chronic racial discrimination and a maternal biomarker measured during pregnancy.

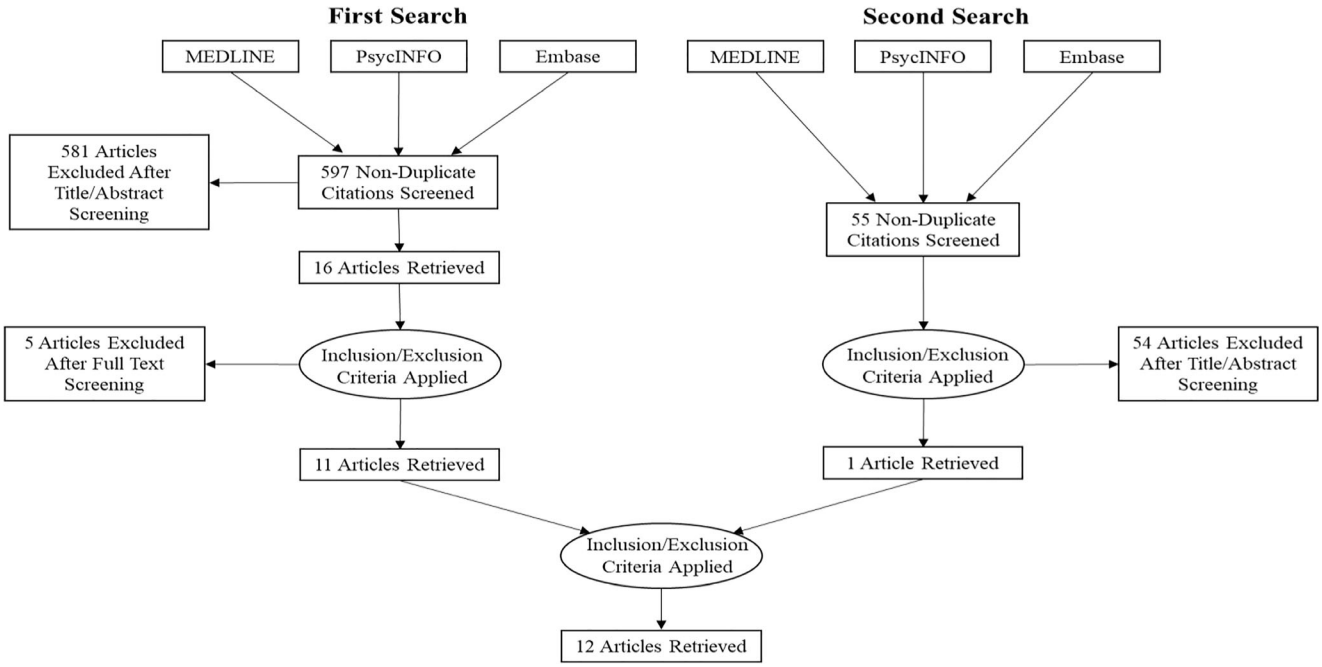

Fig. 2 PRISMA diagram outlining the research synthesis process

While some of the 11 total articles overlapped in the physiological system implicated by their work, we found that articles dealt with biomarkers associated with three systems: immune function (four articles), neuroendocrine function (four articles), and cardiovascular function (four articles). Immune function research focused on Epstein-Barr Virus antibodies and interleukins to investigate the relationship between racial discrimination and immune competence or inflammation. Articles in the neuroendocrine category examined the association between racial discrimination and the hypothalamus-pituitary-adrenal (HPA) axis as an indicator of chronic stress, specifically using cortisol, corticotropin-releasing hormone (CRH), and adrenocorticotropic hormone (ACTH). The final category focused on racial discrimination and cardiovascular function as indexed by blood pressure. We found conflicting evidence that racial discrimination is associated with immune function—either Epstein-Barr Virus antibody levels or interleukin levels—and only indirect evidence that experiences of racial discrimination were associated with neuroendocrine function during pregnancy. Additionally, we found only weak evidence supporting an association between chronic racial discrimination and cardiovascular function measured during pregnancy. Below, we expand upon the included studies as organized by the physiological system investigated.

Immune Function

Based on the selected studies, there is conflicting evidence that racial discrimination may impact immune function and induce inflammatory responses. Two studies investigated Epstein-Barr Virus antibodies. Christian et al. (2012) [46] identified that African American women had higher serum Epstein-Barr virus capsid antigen immunoglobulin G compared with white women across all three trimesters of pregnancy in a sample of 56 pregnant women (38 African American, 18 white). Their study also found that the African American participants who reported the greatest amount of racial discrimination had the highest amounts of serum Epstein-Barr virus levels. No other measure of stress besides racial discrimination was found to have an association with serum EBV levels in African American women. In contrast, Borders et al. (2015) did not find that African American women had greater levels of EBV than white women, although they did observe differences in experiences of racial discrimination and neuroendocrine biomarkers [50].

Two of the identified papers also analyzed the relationship between interleukin levels and racial discrimination [51, 52]. Christian et al. (2013) assessed stress-induced IL-6 responses in 39 pregnant women (19 African American; 20 white) and 39 non-pregnant women (19 African American; 20 white). All pregnant women were in their second trimester and all 39 non-pregnant women were demographically matched to the 39 pregnant women. All participants were asked to complete several measures of psychosocial stress, social support, and racial discrimination. Even after controlling for racial discrimination, social support, and cortisol, Christian et al. (2013) observed large differences in IL-6 responses between African American and white women, both pregnant and

Table 1 Summary information of studies included in the review ($n = 11$)

Author (year)	Participants (% African American)	Mean age	Weeks pregnant when biomarkers collected	Biomarker(s)	Racism or discrimination measure	Main findings
Borders et al. (2015)	114 (49.1%)	Not provided	14–22	EBV, CRP, CRH, ACTH	Self-reported measures of chronic stressors, including discrimination.	African-American women had statistically significantly higher mean CRP and ACTH levels in the 2nd trimester and 3rd trimester. No statistically significant differences in EBV or CRH levels were observed. White women had statistically significant higher buffers against stress and African-American women reported statistically significant greater discrimination
Christian et al. (2012)	56 (67.9%)	23.7	First, second, and third trimester	EBV virus capsid antigen immunoglobulin G (VCA IgG)	Experiences of Discrimination Scale	EBV VCA IgG was statistically significantly lower in the 3rd trimester for both groups. African Americans had higher EBV VCA IgG at every timepoint, and this effect was even stronger for African Americans that had experienced high levels of discrimination. This pattern was not explained by other stress or health behaviors.
Christian et al. (2013)	78 (48.7%)	23.9	13–28	IL6, cortisol	Experiences of Discrimination Scale	IL6 responses post-stressor were statistically significantly higher among pregnant and nonpregnant African Americans than whites. Differences in inflammatory response were not accounted for by demographics, psychological measures, health behaviors, or cortisol.
Giurgescu et al. (2016)	96 (100%)	23.60	15–26	Plasma levels of IL-1β, IL-2, IL-4, IL-6, IL-8, and IL-10	Experiences of Discrimination Scale	Experiences of racial discrimination were associated with statistically significantly higher cytokine levels of IL-4 and IL-6 when controlling for covariates.
Grobman et al. (2018)	9470 (13.8%)	Not provided	6–30	Hypertensive disease of pregnancy	Krieger Racism Scale	African Americans were statistically significantly more likely to experience hypertensive disease of pregnancy than non-Hispanic white women. However, when accounting for discrimination and other covariates, the relationship was not statistically significant.
Hilmert et al. (2014)	39 (100%)	28.7	18–20 and 30–32	Systolic and diastolic blood pressure	Standardized interview that included measures adapted from the Experiences of Discrimination Scale	Indirect childhood and direct childhood racism, but not adult experiences of racism, interacted with DBP to statistically significantly predict low birth weight risk. Change in diastolic blood pressure between the first and second measurement was statistically significantly associated with childhood indirect racism. Women with increased DBP but little or no experiences of racism did not have a statistically significant increased risk of low birth weight.
Simon et al. (2016)	30 (40%)	30.3	32–40	Cortisol awakening response (CAR)	Krieger Perceived Discrimination Scale	African American women exhibited a statistically significantly blunted CAR when compared to white women. Psychosocial stress differed by groups only for perceived discrimination. In multivariate analyses, the cumulative psychosocial stress score was a statistically significant predictor of CAR, but race was not a significant predictor.
Stancil et al. (2000)	94 (100%)	Not provided	First, second, and third trimester	Systolic blood pressure and urinary cortisol	Survey developed specifically for the study.	Predictors of higher systolic blood pressure at 32–36 weeks were younger age, higher BMI, and greater perceived stress. Greater perceived stress was statistically significantly associated with experiences of racism in multivariate modeling.
Suglia et al. (2010)	200 (34%)	26.7	Approximately 28	Cortisol	Experiences of Discrimination Scale	Higher stress was statistically significantly associated with lower morning cortisol and a flatter diurnal rhythm among African American participants. Discrimination was a component of the cumulative stress measure.
Thayer et al. (2015)	80 (50%)	Not provided	Not provided	Blood pressure (MAP), cardiac output (CO), total peripheral resistance (TPR), heart rate variability (RSA)	Experiences of Discrimination Scale	All pregnant women had a significant decrease in MAP. African Americans had impaired vasodilation independent of pregnancy status indexed by greater TPR in spite of greater RSA. Reports of fewer instances of discrimination were associated with greater TPR.
Tse et al. (2012)	176 (26.1%)	Not provided	20–37	Corticotropin-releasing hormone (CRH)	Experiences of Discrimination Scale	Discrimination was associated with CRH levels in a U-shaped pattern among African American women.

nonpregnant. Although African American women reported statistically significantly higher number of and total frequency of experiences of racial discrimination, a high percentage of white women also reported experiencing racial discrimination in one or more major life situation (42%) [51].

Giurgescu et al. (2016) measured plasma levels of IL-1β, IL-2, IL-4, IL-6, IL-8 and IL-10, depressive symptoms, and self-reported racial discrimination in 96 pregnant African American women during their second trimester. They found that having had one or more experiences of racial discrimination was positively correlated with increased depressive symptoms and IL-4 and IL-6 levels, demonstrating an association between racial discrimination and heightened inflammation [52].

Neuroendocrine Function

We found four studies that investigated the relationship between hypothalamic pituitary axis function during pregnancy and experiences of chronic racial discrimination [50, 53–55]. Two of these identified papers investigated the cortisol awakening response (CAR) and found that comprehensive measures psychosocial stress predict differences in CAR [53, 54]. Suglia et al. (2010) measured salivary cortisol in 68 African American and 132 Hispanic pregnant women at around week 25 of their pregnancies. They created a cumulative stress score that incorporated racial discrimination as one component, and greater scores on the cumulative stress measure were associated with a flatter diurnal pattern of cortisol among African American women. However, they did not investigate the independent contribution of racial discrimination to the observed pattern [54]. Simon et al. (2016) similarly studied CAR, but during the third trimester of 18 white and 12 African American pregnant women. They found differences in CAR between African American and white women, and their analyses showed that these differences were associated with psychosocial stress. When they included measures of psychosocial stress in their model, the association between CAR and race was reduced and no longer statistically significant, suggesting that differences in stress may in part explain the relationship between CAR and race. However, they did not include their measure of racial discrimination (the Krieger Perceived Discrimination Scale) as a direct predictor [53].

CRH and ACTH are two other biomarkers of the HPA axis. Tse et al. (2012) tested for blood CRH levels during late pregnancy in 20 white, 46 African American, and 110 Hispanic pregnant women. Their analysis determined that racial discrimination, community violence, and cumulative stress were associated with CRH in African American women, but not in Hispanic women [55]. In contrast, Borders et al. (2015) found no statistically significant differences in CRH levels between African American and white pregnant women in both the second and third trimesters, although ACTH was statistically significantly higher in African American women at both time points. While they did not analyze whether experiences of chronic discrimination were associated with the observed elevated ACTH levels, they did find that African American women had significantly higher rates of racial discrimination, providing weak, indirect evidence that racial discrimination may be associated with elevated ACTH levels [50].

Cardiovascular Function

Four of the included studies examined the relationship between cardiovascular dysfunction and experiences of chronic racial discrimination [47–49, 56]. Two of these assessed blood pressure levels across pregnancy. Hilmert et al. (2014), as described above, found that increases in diastolic blood pressure across mid- to late-pregnancy lead to a greater risk of lower birth weight only when women were exposed to high levels of racism during childhood [48]. Stancil et al. (2000) also investigated systolic blood pressure in 94 pregnant African American women during the first and second halves of their pregnancies. They found that experiences of racial discrimination were associated with greater stress, and greater stress was associated with elevated systolic blood pressure. However, they performed no direct analysis of the effect racial discrimination on systolic blood pressure, providing only indirect support for the influence of racial discrimination on adverse health outcomes [56].

The two remaining studies focused on other cardiovascular biomarkers. Thayer et al. (2015) measured blood pressure as well as cardiac output, total peripheral resistance, and heart rate and found that both pregnant and nonpregnant African American women demonstrated impaired vasodilation related to racial discrimination. While the infants of African American women had lower birth weights compared with those of white women, they did not investigate whether this was associated with either racial discrimination or differences in vasodilation [49]. Grobman et al. (2018) investigated hypertensive disease during pregnancy in 9470 women, 1307 of which were African American. Hypertensive disease was framed as an adverse pregnancy outcome and not a medical issue leading to adverse pregnancy outcomes. They reported that disparities in hypertensive disease between African American and white participants were not explained by differences in self-reported psychosocial factors and that psychosocial factors were not found to be associated with an increased risk of adverse pregnancy outcomes [47].

Discussion

This systematic review found that nine of the 11 included studies indicated that racial discrimination during pregnancy appears to negatively impact African American maternal health

as evidenced by various biomarkers measured during pregnancy. These biomarkers reflected physiological changes in the cardiovascular, immune, and neuroendocrine systems. This result is not surprising since previous work has found that racial discrimination can impact health in various ways [15, 16]. However, the studies discussed in this review distinctly add to the literature by evaluating experiences of chronic racial discrimination and measuring biomarkers during pregnancy in order to demonstrate the ways that chronic racial discrimination in the USA may impact female physiology during a critical period for both the mother and infant. Other work on racial discrimination and adverse pregnancy outcomes fails to analyze the biological pathways that may underlie chronic racial discrimination and adverse birth outcomes. The studies included in this review preliminarily identify the mechanisms underlying this process. Such work is essential to better understand how stress "gets under the skin" and the multitude of ways chronic racial discrimination may affect human biology during pregnancy.

The two studies that did not find a relationship between chronic racial discrimination and a biomarker during pregnancy may have failed to find an effect due to methodological decisions. For example, Grobman et al. (2018) included several medical comorbidities (diabetes mellitus, chronic hypertension, asthma, and kidney disease) in their analytical model to predict hypertensive disease of pregnancy [47]. However, experiences of racial discrimination may contribute to the development of some of these medical comorbidities. In fact, a recent meta-analysis found a significant association between racial discrimination and hypertensive status, where greater experiences of racial discrimination are associated with elevated blood pressure [57]. Thus, the inclusion of these medical comorbidities, particularly hypertension, may have obscured the effects of racial discrimination on their outcome measures. In light of the results of Dolezar et al. (2014) [57], it is possible that their measure of racial discrimination was not a significant predictor of hypertensive disease of pregnancy due to multicollinearity issues between some of the medical comorbidities and their measure of racial discrimination. Thus, Grobman et al. (2018) may have found a result inconsistent with prior research because their inclusion of a "medical comorbidities" variable that could have masked the effect of racial discrimination in the statistical analyses [47].

Additionally, Christian et al. (2013) observed large differences in IL-6 responses between African American and white women, both pregnant and nonpregnant, that were not explained by demographics, health behaviors, cortisol levels, or psychological measures, which included experiences of racial discrimination. Although African American women reported statistically significantly higher number and frequency of experiences of racial discrimination in this study, a high percentage of white women also reported experiencing racial discrimination in one or more major life situation (42%) [51]. Since experiences of racial discrimination will have different psychosocial implications for minority and non-minority members of a population, the failure to find a direct association between interleukin levels and racial discrimination in this study may be a consequence of using a measure of racial discrimination that considers only the number of experiences rather than the psychosocial consequences of racial discrimination for individuals.

Considering the remaining nine studies, this review identified potential biological pathways in the immune, neuroendocrine, and cardiovascular systems that may connect the physiological consequences of experiencing racial discrimination to racial disparities in adverse birth outcomes. However, more nuanced studies are needed that tackle the sociocultural factors related to race and consider individuals' varied responses to racial discrimination. One example of such work is Gravlee, Dressler, and Bernard (2005) [58]. Using ethnographic data, social classification, and skin pigmentation measurements, they found that ascribed color better predicted blood pressure than actual skin pigmentation. This result demonstrates the importance of taking into account sociocultural processes in the study of race. Additionally, future work needs to develop more sophisticated instruments for measuring the stress associated with experiences of racism, which will vary by the individual and even within one's individual experience based on the context. Research should focus on measuring not just the frequency or number of discriminatory events but also the intensity of the event, perceived level of stress in response to experiences of discrimination, and variation in resiliency resources available to individuals [59].

In addition to improved measurements of discrimination, researchers may also need to improve their biological measures of stress. While many of the included articles used either cortisol, IL-6, or CRP as biomarkers of stress, recent work indicates that these widely utilized biomarkers may not be an accurate measure of psychosocial stress as they are currently interpreted [60–62]. These critiques are largely based upon the fact that chemicals in the body have various functions and none respond solely to psychosocial stress [61]. In reference to cortisol, Kim et al. (2015) discuss that the adverse effects of elevated cortisol on cognitive function depend on the psychological conditions surrounding the context in which they are generated [62]. For example, high cortisol due to stress exposures is associated with decreased memory while high cortisol in response to physical activity is associated with increased hippocampal neurogenesis [63]. Critiques of IL-6 and CRP have centered on their role in somatic maintenance efforts, so elevated levels of these markers may not necessarily indicate inflammation [60]. While biomarkers such as cortisol, IL-6, and CRP can be useful measures of biological processes, their many roles in the body must be considered, and levels of these molecules cannot be interpreted as strictly a response to psychosocial stress. Such a nuanced interpretation of these biomarkers was not developed in any of the included articles in this review.

Furthermore, we only included studies that investigated interpersonal racial discrimination. However, structural racism is another phenomenon that likely contributes to maternal and infant racial health disparities. For example, housing segregation is associated with a decrease in employment opportunities, poorer education quality, and decreased access to quality healthcare [see 16]. Even when African Americans have access to quality healthcare, they are more likely to receive lower quality care, a finding that persists after adjusting for differences in health insurance, SES, disease status and severity, and co-occurring illness [21]. The stressful exposures of racial discrimination are multifaceted within the social context of the USA, and the interaction between interpersonal and structural racial discrimination is another necessary avenue of research for understanding the origin of maternal and infant racial health disparities and how best to combat them.

There are several limitations of this review. While meta-analyses can provide more precise and accurate estimates of an effect, we chose not to do a meta-analysis because we aimed at identifying the systems in which chronic racial discrimination is associated with maternal health during pregnancy, which necessitated finding studies with heterogeneous methods. The studies we did include varied in quality, but with only 11 total studies, we did not want to exclude any from the review. While the original aim of this review was to investigate the relationship between racial discrimination, maternal biomarkers during pregnancy, and infant outcomes, we were unable to find research including all three criteria, with the exception of three studies [47–49].

In addition, while 9 of the studies provided some indication that there is a relationship between greater chronic racial discrimination and adverse health outcomes, 4 of those studies provide only weak, indirect evidence [50, 53, 54, 56]. Another criticism that applies to nearly all studies is related to sample size. With some studies including samples containing groups with fewer than 20 individuals, we certainly need not only more work in this research area but also work with larger sample sizes.

Thus, although one of our aims was to identify physiological pathways that have a well-supported relationship between chronic racial discrimination, biomarkers during pregnancy, and infant outcomes, we were unable to do so because only two studies met the criteria. After narrowing our objective to identifying pathways that support a relationship between chronic racial discrimination and biomarkers during pregnancy, the literature provides preliminary evidence that chronic racial discrimination is associated with certain biomarkers during pregnancy. However, the evidence, in both terms of quantity and quality of research, is not sufficiently robust at this time to completely identify the specific biological mechanisms that are implicated in this phenomenon.

Conclusions

Understanding the biological pathways that are influenced by chronic racial discrimination allows us to understand the ways in which the lived experience and health of a mother affects the health of her infant. Because the intrauterine environment not only affects the health of the infant during development and infancy but also their long-term physiology, understanding how the stress of chronic racism manifests in the biology is essential to understanding how intergenerational racial health disparities are biologically perpetuated. This systematic review found that most included studies indicate that racial discrimination leads to biological consequences in the immune, neuroendocrine, and cardiovascular systems during pregnancy. However, we identified only 11 studies that addressed these questions. More research is needed if we are to better understand the myriad ways that chronic racial discrimination impacts biology during pregnancy, and future research should include study designs that account for sociocultural factors and individual variation to advance research in this area. The interaction between interpersonal and structural racial discrimination should also be further studied in addition to their individual contribution to health disparities.

In conclusion, while it is evident that we need to continue to investigate the ways in which chronic racial discrimination contributes to racial disparities in maternal and infant health, this systematic review has shown that the research to date is insufficient in both quantity and quality and has provided suggestions for more robust investigations of possible causal pathways in the future.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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