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REPRODUCTIVE AND PERINATAL EPIDEMIOLOGY (R PLATT, SECTION EDITOR)

Why Do Black Women Experience Higher Rates of Preterm Birth?

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Abstract
Purpose of the Review The goal of this review is to describe how a woman's exposures and experiences lead to Black-white disparities in preterm.
Recent Findings Studies in the last 10 years have increased knowledge in areas that may explain disparities, in particular social factors such as racism and stress, as well as how social factors at the neighborhood level may intersect with those at the individual level. The biologic pathways linking the social environment to disparities in preterm birth is also becoming better understood. Study designs and measures may need to adapt to effectively study disparities.
Summary While there is much greater appreciation for the potential importance of the social environment across the life course, more research is needed on methods to best study these factors, particularly in measurement, as well as pathways linking these factors to preterm birth in Black women.

Keywords Race · Disparities · Pregnancy · Preterm · Racism · Life course · Black · African-American

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Introduction

Reducing racial and social disparities in key perinatal health outcomes such as preterm birth, low birth weight, and infant mortality have been national priorities in the USA for decades [1]. Despite efforts to understand the cause(s) of health disparities in infant outcomes, the gap between White and Black mothers/infants has increased [2, 3]. We will review research on how a woman's exposures and experiences prenatally as well as across her life course are related to disparities in the key pregnancy outcome of preterm birth. We will also describe challenges to studying disparities in birth outcomes and suggest innovative approaches to its study. While the focus of this review will be on the increased risk of preterm birth for Black women in the USA, many of the issues discussed apply to other populations, including other minority groups in the USA and other developed countries, immigrants, and low socioeconomic position individuals.

Risk and Protective Factors Linked to Preterm Birth and Disparities

Research thus far on racial disparities in preterm birth (PTB) has generally focused on whether Black women are more likely to be exposed to risk factors or less likely to experience protective factors. In tandem, there has also been increased attention to the potential for effect modification where similar frequency of exposures by race could produce disparity due to synergy with other exposures. A range of factors have been identified as risk or protective factors that relate to PTB with some of these being particularly salient for Black women. These factors may operate at the individual as well as residential neighborhood level and interact across levels. We first discuss these factors as they relate to exposures and experiences during pregnancy. We then describe contemporary perinatal health frameworks that incorporate the life course and review what is known about these factors in terms of exposures and experiences across the life course and impact on PTB.

Prenatal Factors

Social factors at the individual level were long thought to explain racial disparities. Researchers often suggest that they have "controlled" for differences in socioeconomic status (SES) between Blacks and Whites by including income and education at the time of pregnancy into regression analyses [4–11], but such work has generally failed to fully capture all relevant dimensions of SES [9, 12–15]. Moreover, the historic disenfranchisement of Blacks has produced socioeconomic differences today that are not often ameliorated in one or two generations. While Blacks may now have more opportunities (e.g., education to achieve better employment), the costs of those opportunities may be higher for Black individuals [16]. Related to this, there continues to be well-documented evidence of race influencing financing for homes and vehicles and insurance costs [17, 18]. Even among low-income Black women, while variability in meeting essential needs (e.g., housing, food) may be minimal, there may still be variability in resources for meeting non-essential needs (toys, personal care, restaurant meals). Misra et al. reported that the risk of PTB in a cohort of low-income Black women was doubled for women who lacked resources to meet non-essential needs, even after adjustment for psychosocial factors such as stress [19]. Inclusion of measures of SES beyond education and income may allow for a more complete assessment of SES differences between Blacks and Whites that may underlie disparities in perinatal outcomes [9, 20–23].

An examination of paternal effects may be particularly salient to consider with regard to persistent and substantial Black-white disparities in birth outcomes in the USA. Structural factors associated with socioeconomic position and discrimination suggest that the contribution and role of paternal factors may be different for Black families [24–29]. There may well be paternal risk factors that are relatively more frequent in Black families as well as paternal *protective* factors that can be identified. Furthermore, the maternal risks to which Black women are exposed may increase vulnerability to paternal factors. We have conceptualized a model to examine how fathers may relate to birth outcomes with a particular focus on Black families [30]. Multiple domains are pertinent to an examination of paternal factors in birth outcomes, including their intersection with maternal factors representing potential mediating and moderating pathways. Evidence is emerging that a range of paternal factors, such as fathers' attitudes regarding the pregnancy, fathers' behaviors during the prenatal period, and the relationship between fathers and mothers, may indirectly influence risk for adverse birth outcomes, with implications for potentially explaining racial disparities in this area [31–55]. Especially of interest, an evaluation of a program providing comprehensive prenatal services to Black and White adolescent fathers found that fathers' participation was associated with higher birth weights, a narrowing of racial differences, and a stronger effect on birth weight for the Black infants [33].

Social factors at the residential neighborhood level have been looked to as potentially important risk factors for racial disparities in adverse perinatal health outcomes, given the strikingly different neighborhoods in which Black and White women reside [56••, 57]. While some studies have demonstrated no associations between neighborhood factors and perinatal outcomes such as PTB, others have reported at least some of the neighborhood factors measured to be associated with selected perinatal outcomes [58–62]. Neighborhood factors linked with perinatal outcomes include unemployment [63–67], crime [65, 68–74], safety [75, 76], racial composition (%Black) [77–79], index of neighborhood deprivation or disadvantage (e.g., Townsend Index) [69, 78, 80–83], residential stability [70, 84, 85], median rent [78, 86], wealth or affluence [11, 65, 84], median income [87–91], poverty [77, 92, 93], social support [80, 94], and exchange/volunteerism [70, 95]. A meta-analysis found that high neighborhood disadvantage (administratively defined by US Census data) was associated with 27% higher PTB rates, and 11% higher low birth weight rates, compared to neighborhoods with low disadvantage. More recently, studies of perinatal outcomes have begun to utilize data from surveys of individual residents to self-assessments of neighborhood environment with multi-item scales [70, 75, 80]. Perceptions of neighborhood healthy food availability, walkability, safety, social cohesion, and social disorder have all been found to be associated with PTB [96•] as well as with maternal psychosocial factors such as chronic stress and depressive symptoms [73]. Evidence suggests that perceptions of neighborhood disorder and social cohesion are

associated with increased inflammation and oxidative stress [97, 98], which may link between neighborhood context and adverse birth outcome in Black women. Future research which incorporates various types of neighborhood context measures [99], especially among Blacks [100], is warranted.

Psychosocial factors have received considerable attention over the past several decades with regard both to the etiology of perinatal outcomes like PTB as well as an explanation for Black-White disparities [101–104]. Psychosocial factors include racism-related stress as well as other forms of acute and chronic stress. Early work in this area focused on acute stressors; however, the evidence is mixed [105–112]. Later work expanded the conceptualization of stress in pregnancy to include measures of chronic stress [113]. This shift reflects, in part, critiques noting that chronic strain, not recent events, may be more relevant for poor and minority women and give credence for the integration of a life course perspective. In our past research, we have used a brief measure of stress in which the pregnancy is the recall period but the stress reported is likely the result of a mix of acute and chronic stressors. In two past studies of low-income Black women in Baltimore, we have found a significantly increased risk of preterm birth associated with elevated scores on this stress scale [104, 19]. The complex interactions are illustrated by our recent analysis of our LIFE cohort of Black women in the Detroit area; perceived stress and social support were both found to partially mediate the impact of neighborhood quality on depressive symptoms [73].

Interpersonal racism and discrimination can affect many aspects of life which may affect health, such as economic well-being and residential environment. Evidence linking interpersonal racism or racial discrimination to adverse perinatal outcomes is mixed with both null and adverse findings [114–119, 120•]. The heterogeneity may be due to differences in conceptualization and measurement [121, 120•, 115]. Minorities may experience interpersonal racism or racial discrimination through significant but acute or discrete, observable life events (e.g., being denied a loan); these are often called major experiences of discrimination [122, 121, 123]. They may also experience interpersonal racism or discrimination via subtle, innocuous degradations or put-downs, called microaggressions [124, 120•]. Stress from interpersonal racism or racial discrimination may be personal experiences or those experienced vicariously or collectively as a minority group [122, 125, 126]. The majority of studies examining the relationship between interpersonal racism or racial discrimination and perinatal outcomes have been focused on the impact of major experiences of discrimination [115, 120•]. Finally, racism cannot be studied separately, as there may be mediation and moderation of its impacts. Using data from the LIFE birth cohort of Black women in the Detroit region, we recently reported that the risk of PTB associated with perceived exposure to racism in the form of microaggressions was moderated by depressive symptoms [120•].

Behavioral factors were also long hypothesized to explain racial disparities in birth outcomes. Cigarette smoking, particularly heavy smoking, is an established risk factor for an increased risk of PTB [127]. However, while this appears to be a risk factor for all women, pregnant Black women smoke at lower rates than Whites [128]. Illicit drug use rates are slightly higher but similar for Blacks and Whites in the USA [129]. Even so, independent effects of drugs on the risk of PTB specifically (not fetal growth restriction) have not been consistently reported absent the potential confounding by cigarette smoking and other contextual factors in the environment [130, 131].

Obesity may be another factor relating to disparities in PTB; Black women are more likely to be obese than White women [132, 133]. While recent studies have reported increased risks of PTB among obese women [134–136], results overall have been inconsistent across various studies, obesity subtypes, and PTB outcomes [137]. This particular risk factor may best be examined as a trajectory across a woman's life rather than a state at conception, particularly for Black women who are more likely to be born growth restricted than White women [138].

Physical activity has emerged recently as a possible protective factor for PTB relevant for all women. It may be especially important for Black women, in whom physical activity is infrequent before [139] and during pregnancy [140]. While evidence on physical activity and PTB has expanded considerably in the past three decades, most studies were comprised of White women [141–148] and reported a reduction in PTB risk [149–156, 144, 145] or a null effect [157, 141–143, 146, 147]. The few studies in large cohorts of Black women [158–160] suggest that increasing physical activity could contribute to a significant reduction in PTB among Black women. While the research is encouraging, a number of methodological issues (e.g., measures, threshold effects for timing, and intensity) need to be addressed to reach a more definitive result that can support development of physical activity interventions to reduce PTB. This is especially true of the research on Black women specifically, given the very small number of studies.

Life Course Factors

Epidemiologic research on a wide range of outcomes now examines how factors across the life course, either through accumulation or exposures during critical periods, impact later risk. Since the publishing of seminal papers in the early 2000s [161–163] that advocated for the integration of a life course perspective into maternal and child health research, scholarly work has expanded to include exposures in the year prior to

conception [164, 165]. But intergenerational effects of events and experiences occurring along the maternal life span—starting in early childhood—on perinatal outcomes of women's offspring remain less studied as are the mechanisms by which these life course factors evoke distal effects. The few extant intergenerational studies suggest that events and experiences occurring across a woman's life course may have an effect on future perinatal outcomes [166–185], and these factors have not been fully evaluated in the literature seeking to explain racial differences [20, 181, 186–189]. Exposures and experiences beginning before the prenatal period include social factors and maternal adiposity.

Social Factors: Individual Level Intergenerational studies suggest that the individual level social environment in infancy and childhood has an effect on future reproductive outcomes [166–175, 177]. As yet, studies have considered only birth weight outcomes and not preterm birth. Misra et al., using data which followed the children and grandchildren of women enrolled (1959–1965) in the Baltimore, MD site of the National Collaborative Perinatal Project, found women's in utero exposure to smoke affected the birth weight of their offspring [190]. Maternal SES in childhood and adulthood also each made independent contributions to infant birth weight [191]. Using data from the Pregnancy Outcomes and Community Health Study (1998–2004), Slaughter et al. found that infants born to women whom moved upward in their socioeconomic position between childhood and adulthood had a reduced probability of being small-for-gestation when compared to infants born to women who stayed at the lower socioeconomic position across their life course [176]. Collins et al. also investigated the role of the father's lifelong socioeconomic position and reported that it contributed substantially to the Black-white disparity in low birth weight [192•]. While the cohorts from these studies included White women, Black women were included in substantial numbers. More recently, our team examined SES trajectories among women in our LIFE birth cohort comprised only of Black women. Women who had upward mobility, compared to women whose trajectory remained at the lower static SES, had a reduced risk of their offspring being small-for-gestation [176].

Racism may also influence PTB through experiences that occur across a woman's lifetime and before conception and not just through incidents occurring during her pregnancy. In our cohort of low-income Black women in Baltimore, lifetime racism scores above the median (more racism) were associated with an increased risk of preterm birth in three subgroups with the effect moderated by depressive symptoms and stress [19]. This is an important reminder that social and psychosocial factors may operate in a complex manner related to risk of PTB, particularly for Black women.

Social Factors: Neighborhood Level Few studies have been published on the influence of residential neighborhood social environment across the maternal life course on risk for adverse birth outcomes generally or for Black families. Studies investigating neighborhood effects on perinatal health outcomes have been predominantly cross sectional in nature [56••, 193, 89, 194–196, 85, 197–200, 69]. While there have been exceptions—in the USA, these include the work of Collins and David [177, 179, 185, 201, 180] as well as Kramer [202]—such studies have relied on vital statistics to create their birth cohorts. While vital records allow for the construction of large cohorts for life course research and may increase generalizability, they have several limitations. Studies using vital statistic data are susceptible to inaccurate clinical information [203] and are limited in their ability to control for relevant sociodemographic confounders and to investigate mechanisms that connect residential neighborhood across the life course to perinatal outcomes, as vital statistics lack the "granular information" that can be collected through interviews, record abstraction, and biospecimen collection. Furthermore, cross-sectional ascertainment may not accurately reflect social environments at the neighborhood level since neighborhoods are shaped by economic, social, and political forces exerted over several decades [204•, 205, 206]. Static measures of the neighborhood environment are likely biased toward the null, because they cannot account for the potential indirect effects through time-varying characteristics of families, including structure, occupation, income, and marital status [207]. Hence, there remains a knowledge gap regarding the historical, life course, or cumulative impacts of maternal exposures to neighborhood social environment on perinatal health.

Pathways Linking Risk and Protective Factors to Birth Outcomes and Disparities

There has long been research on the final biologic pathways in the pathogenesis of PTB. There has, however, been little success in modifying these proximate triggers, once identified. While successful prevention requires knowledge of the more distal (prenatal and life course) determinants, the pathways between such factors and the final biologic triggers must also be studied. Research needs to consider not only how distal factors affect risk but also how downstream factors may mediate and/or moderate their impact.

Systemic inflammation during pregnancy is one of these downstream factors through which the distal determinants may impact birth outcomes. During pregnancy, the immune functions are regulated by a complex array of cytokines [208, 209]. Mid-pregnancy is a predominantly anti-inflammatory phase which contributes to the maintenance of pregnancy [209, 208, 210]. Toward the end of pregnancy, however, there

is a switch from anti-inflammatory to pro-inflammatory pathways which stimulate uterine contractions resulting in cervical ripening, rupture of membranes, labor, and birth [209, 208, 211, 210]. Chronic stress, however, can activate these pro-inflammatory pathways earlier in pregnancy by an increase release of cortisol from the hypothalamic-pituitary-adrenal (HPA) axis. Cortisol is potently anti-inflammatory, and normally, activation of the HPA axis counter-regulates immuno-inflammatory responses [211, 212]. However, during chronic stress, cortisol is less effective in regulating the inflammatory responses, and therefore, there may be a shift of the immune system into a pro-inflammatory state earlier than normal which can increase the risk of PTB [209, 211, 213, 208]. Findings from small studies suggest that pregnant women with higher levels of stress have higher levels of cortisol and pro-inflammatory cytokines and lower levels of anti-inflammatory cytokines [213–222]. Studies have also found that women with PTB have higher levels of cortisol and pro-inflammatory cytokines as early as the mid-pregnancy compared with women with term birth [223–229, 218, 230, 215, 231, 232, 217, 233–238]. Interestingly, Black pregnant women have higher hair cortisol [239], a novel biomarker of chronic stress [240, 241], and systemic inflammation [242, 243] than Whites, suggesting that they experience higher chronic stress. In one study, Black women with PTB had higher systemic inflammation than those with term births; such differences were not observed in Whites [229]. These findings support the hypothesis that chronic cumulative exposure to stress experienced by Black women may increase their systemic inflammation and ultimately risk for PTB. Indeed, we found that Black women who reported racial discrimination had higher serum levels of interleukin(IL)-6, a pro-inflammatory cytokine, compared with women who did not experience racial discrimination [244]. Thus, systemic inflammation is a potential pathway by which social factors increase the risk of negative birth outcomes.

Omics during pregnancy is a very new area of research with regard to the biologic pathways that underlie the pathogenesis of PTB. Publications on omics and PTB thus far have primarily considered the role of the maternal proteome [245] and microbiome [246]. The lipidome and metabolome have also begun to be investigated. Studies in proteomics, lipidomics, and metabolomics have generally been small, and replication of results continues to be a challenge [245]. The published literature on the lipidome and metabolome has not yet been sufficient to merit a review, but studies have begun to appear that suggest associations with PTB [247, 248]. Considerably more studies of the microbiome and PTB, particularly the vaginal microbiome, have been published in the past decade, but there is still little consensus and replication of results across studies.

There has been little attention to racial and ethnic heterogeneities and how omic factors may relate to PTB among Black women specifically or explain the racial disparity. Furthermore, few omic studies have included diverse samples with sizeable numbers of pregnant Black women to allow for race-specific analysis. While the 2016 report of Saade et al.'s proteomic study [249] included approximately 900 Black women within the cohort of 4509 pregnant women followed to delivery, the cohort was low risk (<5% rate of PTB), and none of the results were stratified on race. In recent work on the vaginal microbiome, we reported that a number of bacterial species were each associated with an increased risk of PTB in heterogeneous cohort than included approximately equal numbers of Black, Hispanic, and White women. Most strikingly, the racial/ethnic group modified nearly all of these associations with PTB, with the effect of specific taxa on risk as well as the prevalence of the taxa varying by racial/ethnic group [250].

Epigenetic factors are another potential pathway, defined as molecular modifications that alter gene activity but do not change the sequence of the gene [251]. DNA methylation and histone modifications, the two most studied types of epigenetic processes [252], have been shown to be responsive to early-life environmental exposures in various gene regions [253]. Epigenetics and its subjectivity to environmental influences during developmental stages of pregnancy hold the potential for the discovery of biomarkers to identify women at risk for adverse birth outcomes [254]. Several studies have discovered differences in DNA methylation in mothers experiencing PTB and maternal stress [255–257]. Finally, Salihu et al. (2016) [258] identified gene methylation sites that showed significant differences between Black and non-Black newborns. Studies in the causes and implications of epigenetic changes and differences are in their infancy, but they may well lead to the discovery of biomarkers or the ability to gauge intergenerational risks and significantly decrease negative birth outcomes.

Innovative Approaches to Study Design and Analytic Methods to Study Vulnerable and Marginalized Populations

We describe in this final section proposed innovative approaches to study design and measurement that are needed to advance research in this area.

Black-Only Study Design While the "environment" for a woman certainly differs by race in the USA, variability of pregnancy outcomes and exposures within the subpopulation of Black women often goes unexamined when research focuses on Black-white comparisons. Understanding the causes of the disparity and identifying solutions requires studies which examine risk and protective factors within the population of Black women. While countless studies have reported on the

disparity in adverse birth outcomes, most have relied on vital statistics or institutional databases. Studies which have engaged in primary collection of data on risk and protective factors have rarely included Black respondents in numbers sufficient for analyses to stratify on race. This is critical for the study of factors that may be unique to Black women, such as the experience of racism, or when the assessment of effect modification is an aim. We have repeatedly found evidence that effects of such factors are indeed complex and are modified and mediated by other factors [259, 104, 19, 120•, 122, 125, 126].

Beyond studying unique factors and interactions, we also argue that restriction is necessary to address the fundamental incommensurability of measures of social environmental exposures for Blacks and Whites [260]. As reviewed by Kaufman [260], adjusting for education is an insufficient control of socioeconomic differences because education does not produce the same material benefits for Blacks as for Whites with wealth and income inequities pervasive within educational strata. Incommensurate measures are liable to produce residual confounding. Furthermore, stratification and multiple regression techniques cannot accommodate the extreme confounding likely to occur for factors such as racism where the distribution of the variables may widely vary and therefore produce empty cells.

Finally, we turn to the literature on counterfactuals to understand the fundamental difficulty in employing White women as a comparison group. The adequacy of a comparison group rests upon its ability to yield an accurate estimate of the risk that would have been experienced by the exposed group in the absence of the exposure [261, 262]. Kaufman and colleagues articulate this problem with regard to a hypothetical study of gender and depression. "On the basis of the underlying counterfactual interpretation of this approach, the researcher would in fact be posing the query, 'What would the risk of depression have been for this individual had she not been a woman?' While an adequate explication of this argument requires substantially more detail, it suffices in this context to note that causal inference related to essential attributes, rather than modifiable states, raises insoluble problems…" [260]. Race is similarly problematic; in that, the pathways we propose to study have no plausible counterpart for women who are not Black. Morgenstern asks, "…do we want to compare the observed outcome risk in a Black population with what the risk would have been if everyone in this population would have been born White? …What variables or conditions would we want to hold constant to assess this contrast—the race of their parents or ancestors, their sociocultural heritage, their educational and occupational achievements or opportunities, their experience with discrimination or injustice…" [263].

Timing of Cohort Recruitment Cohorts established prospectively often recruit from prenatal clinics which may lead to a bias toward women who have early and/or consistent prenatal care and whom have lower-risk profiles than women who are unable to be recruited due to multiple missed prenatal care appointments, late, interrupted, or sporadic care [264–268]. Investigators have consistently demonstrated that women who receive inadequate prenatal care are at increased risk for adverse perinatal outcomes [264–268]. While prenatal care may not be the causal factor influencing outcomes, it is a marker for risk in the population of pregnant women.

If these subgroups of women are systematically more likely to be excluded by this particular design, two problems may arise. First, the prevalence of the exposure and/or outcome may differ. Prior studies suggest that participants in a prospective cohort study of pregnancy are lower risk in terms of both exposures and rate of PTB. For example, in our Baltimore study (2000–2004) [120•], our postpartum recruited group included women with late or no prenatal care as well as women with care who we had been unable to reach prenatally. Women recruited postpartum had a higher PTB rate as well as being more likely to engage in unhealthy behaviors. Findings from a large-scale carefully conducted prospective cohort study, known as the Pregnancy, Infection, and Nutrition (PIN) study, also demonstrate the potential problem with this design. PIN recruited women prenatally from clinical sites. PIN PTB rates were compared to rates from vital statistics for the corresponding population. For Whites, PIN participants were at similar risk for PTB. For Blacks, PIN participants experienced substantially lower PTB rates than area women [269]. The sample of women recruited with this design were at lower risk, which may have effects on both understanding etiology among higher-risk women as well as constraining predicted statistical power to detect effects of exposures.

Second, a prospective cohort design may result in bias such that the relation between exposure and disease is different for those who participate and those who would theoretically be eligible for the study but do not participate [262, 270]. Eligibility might be defined with respect to receipt of consistent prenatal care but ideally would relate only to pregnant women from the underlying population. Recent analyses of the PIN study again make the point that concern about heterogeneity in effect estimates may be warranted. While Black women in the community were nearly two times more likely to deliver preterm than White women, PTB rates were similar for Black and White women enrolled in PIN. Differences were even more pronounced for very PTB. The association (stratified by race) between maternal education and PTB also varied, with little effect of education on PTB among Black PIN participants but a protective effect among Black women in the area community [269].

The preference for prospective studies beginning earlier in pregnancy, often referred to as the gold standard, has not taken account of the limitations described here. This reliance has

stemmed in part from the interest in developing prenatal biomarkers of risk that can be used to identify and then intervene with women prior to development of adverse birth outcomes. Certainly, studies recruiting women at birth cannot study biomarkers that could be used to screen women clinically. However, biologic measures collected at delivery can reflect exposures that occur prenatally. The placenta is a source of biologic data that provides a window on exposures beginning even early in pregnancy [271]. Another potential biomarker that can be collected postpartum and provide a measure from the prenatal period is hair cortisol. Hair cortisol is less subject to daily fluctuation than salivary cortisol and a novel biomarker of chronic stress [240, 241] that could capture exposures across the pregnancy.

Beyond Prenatal Care: Alternative Recruitment Sites It is challenging to recruit pregnant women through prenatal care in such a manner that it results in an unbiased and generalizable sample. This is obviously critical for Black women who are less likely to receive adequate and timely prenatal care. We have undertaken one approach which recruits women at the point of delivery and collects data by interview and record abstraction. While new laboratory assessment methods may enable biologic measures to be collected postpartum that can reflect prenatal exposure, ideally, approaches are also needed to recruit pregnant women outside of prenatal care settings. One approach still linked to care seeking would be to screen and recruit during emergency department encounters. Even with the tremendous expansions of public insurance coverage and subsidies for care, women, particularly low-income and minority women, continue to seek care from emergency departments in large numbers.

Measurement to Assess Cumulative and Life Course Exposures Attention is increasingly being given to the potential importance of cumulative and life course exposures that may relate to adverse birth outcomes and Black/White disparities to prospectively follow participants across their life span as well as intergenerationally requires time and resources that may not exist. Potentially external data, such as collected in surveys or vital record registration, could be used to provide data across the life course and across generations. Such an approach was taken by Collins et al. [192•] to examine the impact of maternal and paternal early social environment on birth outcomes of the next generation. Parental proxies may be an efficacious alternative to capturing a range of exposures occurring in the early childhood of individual's life span. Yet, only a handful of life course perinatal epidemiologic studies have incorporated the use of proxy reporting by mothers of women (grandmother of the index child) to collect women's early childhood exposures and outcomes [272–276]. In the LIFE cohort, we utilized both proxy- and self-reporting to ascertain information related to the social, psychosocial, and biomedical environment across the maternal life course [276, 275••]. Our validation study showed positive associations between LIFE women and their mother's retrospective reports for the body weight, health, and socioeconomic position during LIFE women's childhood [276]. We also considered residential environment derived from addresses and perceptions over the life course, comparing subjective to objective data [275••] and comparing reports from mothers and grandmothers (unpublished results). Longitudinal data could allow investigators to take into account the accumulation of exposures across neighborhoods, with a multiple membership model, or separating out the effect of different kinds of neighborhood exposures with a cross-classified model [277]. Our findings suggest that retrospective reports of individual and neighborhood environments may be a cost-effective, valid, and reliable method to examine how the social environment over the maternal life course may independently, cumulatively, and interactively impact perinatal outcomes.

Biologic measures may enable the integration of early and cumulative exposures. Telomere length has increasingly been examined as one such biomarker. Telomere attrition occurs with age but may be accelerated by chronic psychological stress [278–280]. Evidence has shown telomere shortening to be a predictor of health status and longevity [281, 282]. A recent study found that perceptions of neighborhood context was associated with shorter telomere length, even after controlling for individual level covariates, among Black women, but not men [283]. Epigenetic modifications, discussed briefly in our prior section on pathways, may also act as biomarkers of exposure to stressors across the life course [284]. Changes in DNA methylation across the life course and in response to acute stress have been documented [285]; however, the degree to which lifelong psychosocial stressors impact DNA methylation and pregnancy outcomes remains understudied.

Conclusion

While promising research is emerging, efforts to identify strategies to reduce risk require a better understanding of the problem and its causes. We need bold research that encompasses the complexity of women's lives in the context of their family, community, and nation and her experiences and exposures are over her life course. Changes at the individual, community, and national level are needed to close the gap and eliminate disparities in PTB.

Compliance with Ethical Standards

Conflict of Interest Dawn P. Misra, Jaime Slaughter-Acey, Carmen Giurgescu, and Shawnita Sealy-Jefferson each declare no potential conflicts of interest.

Alexandra Nowak reports other from Wayne State University, outside the submitted work.

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Papers of particular interest, published recently, have been highlighted as:
- • Of importance
- •• Of major importance

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