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Stress and Stress Reduction

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Abstract: Chronic stress contributes to preterm birth (PTB), through direct physiological mechanisms or behavioral pathways. This review identified interventions to prevent PTB through decreased maternal stress. Studies were grouped according to intervention: group prenatal care (11 studies), care coordination (8 studies), health insurance expansion (4 studies), expanded prenatal education/support in the clinic (8 studies), home visitation (9 studies), telephone contact (2 studies), or stress-reduction strategies (5 studies). Group prenatal care had the most evidence for PTB prevention. Comparative studies of PTB prevention through different models of prenatal care and maternal support, education, empowerment, stress-reduction, and coping strategies are needed.

Key words: stress reduction, preterm birth, low birthweight, *CenteringPregnancy*, group prenatal care, intervention

Introduction

Preterm birth (PTB), defined as delivery at <37 weeks of gestation, is a major cause of perinatal mortality, and is the leading cause of infant morbidity in the United States. Although the PTB rate in the United States has been declining since 2006, it remains higher than those in previous decades,[1] and is significantly higher than that of other industrialized countries.[2] Infants that are born prematurely have an increased risk of neonatal mortality, as well as a greater risk of short-term and long-term health problems such as respiratory disease, blindness, and cerebral palsy. Infants born even just a few weeks early are at a substantially increased risk of death and disability when compared with infants born at term.[3] The estimated societal economic impact of PTB is approximately $26.2 billion annually.[4] PTB is a huge medical and economic burden making preventing PTB a priority.

One potential contributor to PTB is chronic stress, acting through direct physiological mechanisms or through behavioral pathways, like drug use, nutritional intake, and the timing and frequency of seeking medical care. For this paper, we will define stress as the perception of recognition that an insult has occurred and/or the entire process of experiencing, perceiving and responding to a stressor (a theoretically objective event that occur to

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individuals).[5] This view draws on a classic model holding that when stimuli, commonly referred to as stressors, are appraised as threatening and unmanageable, they elicit a psychological state that is experienced as stress, as well as a cascade of behavioral and biological adjustments, commonly referred to as responses.[5] Thus, in the rest of the paper we use "stress" as an umbrella term, meant to capture times when a women has been exposed to a stimulus and judged it to be a threat she cannot manage.

BIOLOGICAL PLAUSIBILITY

At least 3 physiological pathways suggest the biological plausibility of a link between chronic stress and PTB.[6] First, stress increases expression of corticotrophin-releasing hormone (CRH), both centrally and in the periphery, and by doing so may upregulate inflammatory cytokine release from the decidua and amnion, which in turn stimulate myometrial contractions,[7–9] that lead to preterm labor.[10–12] In addition, increased maternal serum levels of CRH in the second trimester of pregnancy are found in women who deliver prematurely.[13,14] Second, chronic stress down regulates many functions of T and B lymphocytes, including proliferation, differentiation, and cytotoxicity.[15,16] This stress-related reduction of lymphocyte activity increases host resistance to viral pathogens, and some bacteria. These infections may act as cofactors that precipitate PTB.[6,17,18] Third, chronic stress activates cells of the monocyte/macrophage lineage, stimulating a chronic, low-grade, inflammation, marked by increased systemic levels of cytokines (IL-6, TNF-a, IL-8) and acute phase proteins (C-reactive protein).[19,20] In part, this stress-related inflammation occurs through down regulation of anti-inflammatory signaling through the glucocorticoid receptor.[21,22] Essentially, chronic stress renders monocytes and macrophages insensitive to glucocorticoids' anti-inflammatory properties. Trivial inflammatory stimuli may then result in excessive cytokine production, stimulating myometrial contractions and PTB.[23] Elevated CRP, an acute phase protein often used a marker of inflammation, has been shown to be associated with chronic stress and has been reported in association with PTB.[24–26] Moreover, a recent study linked higher levels of pregnancy-specific distress, with increased levels of IL-6 and TNF-α and lowered the gestational age at delivery.[27]

EPIDEMIOLOGIC PLAUSIBILITY

In addition, there is epidemiologic evidence linking chronic stress and PTB. Multiple studies, including a recent review of over 80 investigations[28] have shown a link between increased self-reported maternal stress and low birthweight (LBW) or PTB.[23,29–35] However, other studies have not demonstrated this association.[36–40] One reason for this inconsistency may be related to the many ways that studies have defined and measured stress, not all of which adequately capture the kinds of prolonged, unmanageable threats that would fall under the definition above.[41] Maternal stress has been measured variably including: stressful life events, anxiety, depression, stressful work, physical abuse, perceptions of neighborhood discrimination, and low levels of social support. In many cases the frequency and duration of stress exposure has not been ascertained. Also, multiple studies have focused on isolated stressful life events, which in many cases have involved acute stressors that would be expected to pose minimal threat or resolve quickly. Kingston et al[42] proposed a model integrating psychological, social, and demographic factors over the life course through a number of direct and indirect pathways to link perceived stress in childhood to perinatal stress mediated by social support, socioeconomic position, and family relationships. In addition, recent evidence supports the concept that cumulative exposure to chronic stressors

from hardships associated with adverse socioeconomic environments are more highly associated with poor health outcomes.[43–45] The increasing evidence linking pregnancy-specific anxiety and stress to PTB and LBW babies has lead the Office of the Surgeon General and the Eunice Kennedy Shriver National Institute of Child Health and Human Development to recommend further research into resolving pregnancy-related stress and anxiety through interventions that will likely need to be varied based on differences in ethnic, cultural, and socioeconomic status (SES).[46,47]

CHRONIC STRESS AND RACIAL DISPARITIES IN PTB

Chronic stress may also explain some of the racial disparities evident in PTB rates in the United States.[23,35,48–50] As a group, African American women in the United States have been hypothesized to be under higher levels of chronic stress due to racism and discrimination, job instability, economic difficulties, and lower access to resources. In a case-control investigation, African American mothers' perceptions of poor neighborhoods and increased stress were found to be associated with significantly increased odds of having a very low birthweight (VLBW) child.[51,52] In addition, a higher lifetime exposure to interpersonal racism has been correlated with significantly increased odds of VLBW infants even when controlling for demographic, biomedical, and behavioral variables. Few studies have documented increased psychosocial stress during pregnancy in African American women compared with other racial groups.[53,54] Dole et al[35] reported that some associations between psychosocial variables and PTB varied by race. African American women reported higher perceived discrimination, poor neighborhood safety, and a greater number of negative life events. However, other markers of perceived stress were not associated with increased rates of PTB among African American women.

Two conceptual models of chronic stress have been proposed to explain racial disparities in rates of PTB: life course theory[44] and "weathering."[48] In the life course theory model proposed by Lu and Halfon, racial disparities in LBW reflect a greater prevalence of prepregnancy contextual risk factors and a lower prevalence of prepregnancy protective variables among African American women. Life course factors influence pregnancy outcome through 2 proposed mechanisms: early-life (fetal) programming of reproductive potential and cumulative wear and tear (weathering). Although extremes of maternal age are risk factors for PTB and LBW in whites, the risk of LBW for African American women grows monotonically with advancing age.[55–57] This deterioration in African American reproductive health has been termed "The Weathering Hypothesis"[57] and it conceptualizes the physical consequences of social inequality on female reproductive outcomes. A recent study found that the weathering pattern of maternal age and infant birthweight was limited to African American women with lifelong residence in low-income urban neighborhoods.[58] According to David and Collins,[59] by assuming that racial disparities in PTB are a result of numerical differences in conventional risk factors, researchers and physicians overlook nonrandom, pervasive, and multifaceted inequality that is bound up in the historical context of race. Indeed, it has been shown that African American mothers who delivered prematurely were more likely to experience interpersonal racial discrimination during their lifetime than African American mothers who delivered at term.[59]

INTERVENTIONS TO REDUCE MATERNAL STRESS

Given the literature supports an association between chronic stress and PTB and supports that chronic stress may contribute to the racial disparities evident in the PTB

rates in the United States,[23,30,51,55] it is imperative that interventions aimed at reduction of maternal stress be identified and rigorously evaluated. There are many potential stressors affecting women in pregnancy including financial problems, neighborhood conditions, discrimination, strain in intimate relationships, family responsibilities, employment conditions, and pregnancy-related concerns.[60] A varied set of prenatal interventions have been reported that may serve to reduce maternal stress. These interventions range from: improved patient support and education in the clinical setting, group support, outreach with home visitation or phone calls, to teaching stress-reduction and improved coping mechanisms.

A review of all interventions aimed at maternal stress-reduction and evaluation of PTB outcomes has not previously been reported. This review sought to identify studies that investigated interventions to decrease maternal stress with PTB as a measured outcome. As gestational age and fetal weight are often correlated with infant outcomes, we also included studies that evaluated reduction in LBW (< 2500 g).

Methods

SEARCH STRATEGY

A literature search was performed in the fall of 2013 with MEDLINE, Ovid, and PubMed databases using a combination of keywords and MeSH terms that included both outcome terms (PTB and LBW) and intervention terms [psychosocial, stress reduction, stress intervention, self-efficacy, centering of pregnancy, group prenatal care, coping, social support, mindfulness, and Nurse-Family Partnership (NFP)]. In addition, the NIH clinical trials registry was searched for any studies on PTB, prematurity or LBW that related to stress and stress reduction. Also, studies on any form of stress reduction and pregnancy were queried using the intervention terms "mindfulness, stress-reduction, coping skills, complementary medicine, and/or alternative medicine" and outcome terms of "pregnancy" to search for studies with birth outcomes as a secondary focus of the study. Studies were limited to those in the English language. The literature search was performed by 2 researchers (H.S. and S.Q.). Only articles published after 1980 were included in this assessment, given that studies conducted before that time generally did not have a standardized definition of PTB.[61] The references from retrieved studies were reviewed to assess for other publications not found with the original search.

STUDY SELECTION CRITERIA

Titles were reviewed by 2 researchers (H.S. and S.Q.) for relevance to study question, if there was a disagreement, the study was included for further review by an additional researcher (A.B.). The abstracts were reviewed for suitability based on 2 criteria (1) there was a formalized attempt to decrease prenatal stress or provide additional prenatal support before birth; (2) the outcome studied was PTB or LBW.

DATA EXTRACTION

Each of the selected studies was reviewed for study design, number of participants, intervention, outcomes, and findings including any attempts to control for confounding factors.

Results

The literature search found 330 articles for review. After removing non-English language publications, excluding duplicates, and examining the article titles, 139 articles remained for review. Of those, many were excluded for having content not directly related to the study question ($N = 49$) and many were excluded for documenting an association between stress and PTB but not testing an

intervention (N = 42). One study was unable to be retrieved from the journal archives. The remaining studies were grouped according to similar types of intervention including group prenatal care (11 studies), care coordination (8 studies), expansion of public health insurance (4 studies), expanded prenatal education/support either in the clinic (8 studies) through home visitation (9 studies) or telephone contact (2 studies) or teaching stress-reduction strategies (5 studies).

CARE COORDINATION

Care coordination, or case management, can be broadly described as a way of helping vulnerable populations identify the areas where they need assistance, and then connecting them to relevant resources in the community. This individualized care ensures that a person is linked to the most cost-effective and highest quality services that will meet their needs.[62] Care coordinators, who can be social workers or health care providers (ie, nurses), are able to provide women with social and emotional support which can help reduce stress during pregnancy. Findings have varied among studies (see Table 1 for study overviews for Care Coordination).[63–70] Researchers in South Carolina identified women at high risk for PTB and referred them to case management, which included 24-hour access to a perinatal hotline. In the county that had the program there was a significant improvement in the distribution of PTB that occur <28 weeks [1.6% vs. 1.1%, $P = 0.029$, relative risk (RR) = 0.75; 95% confidence interval (CI), 0.51-0.96].[64] In addition, they found that there was a significant decrease in NICU admissions (6.7% vs. 5.8%, $P = 0.04$) and a decrease by >4 days in the average length of stay in the NICU with the care coordination. Women identified as high risk for PTB in Manchester, England were given access to family worker services, which provided individualized care; no significant difference was found in the rates of PTB rate or LBW.[63] A smaller sample size, the possibility that the intervention was not sufficient, and the possibility that women who would have benefited from family worker services were not included were cited by the authors as probable reasons for this result. Similarly, an intervention that used a telephonic case management model,[66] and another that offered group prenatal care with complementary case management as part of the Black Infant Health Program,[65] found no significant differences in PTB.

A few of the studies with some promising findings focused on LBW. Medicaid-eligible women in the Prenatal Plus program in Colorado worked with care coordinators to resolve risks during their pregnancy, including smoking, inadequate weight gain, and psychosocial problems. Women who were able to successfully resolve risks greatly reduced the risk of a LBW delivery.[68] Buescher and colleagues evaluated the impact of maternity care coordination on Medicaid-eligible women in North Carolina. Women who were in the Baby Love Program (which helped eliminated barriers to client's use of services) had significantly fewer LBW and VLBW babies (8.67% vs. 10.50%, $P < 0.0001$ and 1.23% vs. 1.99%, $P < 0.0001$, respectively).[69] HealthStart, a similar program for Medicaid-eligible women in New Jersey involved case managers coordinating care during pregnancy and postpartum. Although there was little effect on birthweight for white women enrolled in the program, the results were significant and favorable for black women; those who received coordinated care (10,908 women) had a lower rate of LBW births compared with the controls (8617 women) (0.114 vs. 0.158, $P < 0.01$) and lower rate of VLBW births (0.017 vs. 0.031, $P < 0.01$).[70]

There are promising, although mixed results about the efficacy of care coordination to reduce the rate of PTB and LBW babies. Some studies suggest that care

TABLE 1. Care Coordination

References	Study Design	Participants	Intervention	Preterm Birth Findings	Low Birthweight Findings	Conclusions
Spencer et al[63]	RCT	626 women with high risk of LBW	1-2 weekly visits by family worker, using a client-centered approach to provide services such as obtaining state benefits, housing, shopping, domestic work/ childcare, promote appropriate use of health and social services/ community facilities, acting as a confidante	Women with intervention had NS difference in PTB rate (10.0% vs. 9.3%) OR = 1.1 (95% CI, 0.7-1.6)	Women with intervention had NS difference in all LBW babies (8 vs. 8.6%, OR = 1.0 (95% CI, 0.7-1.6). Women with intervention had NS difference in live-born LBW babies (8.7 vs. 8.4%, OR = 1.0 (95% CI, 0.7-1.6)	NS
Newman et al[64]	Prospective cohort	317 Medicaid recipient women compared with historical controls	Telephonic assessment for risk of preterm birth, education and referred for case management. Women were also give access to a 24/7 perinatal hotline	Compared with historic controls, improvement in PTB < 28 wk, 28-31 6/7 wk, and 32-36 6/7 weeks ($P = 0.05$) primarily confined to deliveries < 28 wk 1.6% vs. 1.1%; $P = 0.029$, RR = 0.75 (95% CI, 0.51-0.96)	Compared with historic controls no improvement in distribution of ELBW, VLBW and LBW infants ($P = 0.056$)	Telephonic risk assessment appears to lower the distribution of PTD, particularly deliveries < 28 weeks, but does not appear to have an effect on the birthweight
Willis et al[65]	Prospective observational study	1553 women involved in the BIH program compared with 11,633 women not in the BIH program	Women in the BIH program received twenty group sessions (10 prenatally, 10 postpartum) with complementary case management, designed to encourage and support a healthy pregnancy	The PTB rates were the same in both groups (17.9%)	The rate of LBW infants was similar between BIH participants and controls, 14.9% vs. 14.1%, OR = 1.07 (95%v CI, 0.83-1.38), $P = 0.61$	Group PNC with case management did not decrease the rates of PTB and LBW infants
Little et al[66]	RCT	61 low-income, high-risk women compared with 50 controls	Telephonic case management model developed by ROSEBUD[r]—coordination of care including home services and clinic appointment, coordination of interventions requested by care providers w/consideration	Multivariable regression model showed no significant impact of case coordination on preterm birth	NA	NS

TABLE 1. (Continued)

References	Study Design	Participants	Intervention	Preterm Birth Findings	Low Birthweight Findings	Conclusions
			given to cost-effective and quality-effective alternative, patient advocacy (teaching self-advocacy in health care to patient and encourage patient to be involved in care and help create care plan			
Gonzalez-Calvo et al[67]	Observational	210 low-income African American women with creasy risk score > 7	Case workers visited women at least once a month until baby was 12 mo old. (1-2 times/wk if issues). Summarized as percentage of problems solved/total problems. Problems included barriers to care, lack of knowledge or social support	NA	NS relationship between problems solved and LBW ($r = 0.164$, $P < 0.10$)	NS
Ricketts et al[68]	Retrospective cohort	3569 Medicaid-eligible women with resolved risks were compared with women with unresolved risk	Care coordination through prenatal plus program. Prenatal interventions targeted to resolve risks including smoking, inadequate weight gain, psychosocial problems	NA	Women who resolved all risks had less LBW (7.0% vs. 13.2%, $P < 0.001$)	Intervention decreases LBW
Buescher et al[69]	Retrospective cohort study	2684 Medicaid eligible received care coordination vs. 19,651 no care coordination	Care coordination aimed at eliminating barriers to client use of services to address medicinal, nutritional, and psychosocial resource needs. It also was aimed at social and emotional support for stress reduction and adoption of healthful	NA	After controlling for receiving prenatal care, women who received care coordination had significantly fewer LBW babies (8.67% vs. 10.50%, $P < 0.0001$) and VLBW (1.23% vs. 1.99%, $P < 0.0001$)	Care coordination decreases LBW and VLBW

TABLE 1. (Continued)

References	Study Design	Participants	Intervention	Preterm Birth Findings	Low Birthweight Findings	Conclusions
			behaviors in pregnancy			
Reichman and Florio[70]	Retrospective cohort	Medicaid-eligible women in New Jersey *Black*: intervention (10,908), nonintervention (8617) *White*: intervention (13,128) nonintervention (8102)	Healthy Start program-case managers provided care coordination during pregnancy and postpartum. Provides outreach to attempt to attract women to care earlier	NA	Black women who received coordinated care had a lower rate of LBW births compared with controls (0.114 vs. 0.158, $P < 0.01$) and a lower rate of VLBW births (0.017 vs. 0.031, $P < 0.01$). Multivariable logistic regression for birthweight in black women showed a reduced probability of LBW 0.037 and VLBW by 0.009. White women who received coordinated care had a lower rate of LBW births compared with controls (0.069 vs. 0.080, $P < 0.01$) but NS difference in VLBW births (0.011 vs. 0.014)	Care coordination decreases LBW and VLBW in black women, and LBW in white women.

BIH indicates black infant health program in California; CP, Centering Pregnancy; ELBW, extremely low birthweight (< 1000 g); LBW, low birthweight (< 2500 g); NA, not applicable; NS, not significant; PNC, prenatal care; PTB, preterm birth (< 37 wk gestational age); RCT, randomized controlled trial; SES, socioeconomic status; VLBW, very low birthweight (< 1500 g).

coordination can reduce PTB rates, reduce neonatal care costs, and improve birthweight, particularly in minority groups. Part of this heterogeneity may be attributed to the fact that an intervention coordinating care can encompass a wide/varied range of activities and identifying exactly which aspect of a care coordination intervention is attributed to the improvement in birth outcome is needed. It is unclear how much of the improvement is related to stress reduction (not measured in the studies) which will in the future need to be specifically evaluated.

CENTERINGPREGNANCY AND GROUP PRENATAL CARE

Group prenatal care, particularly the *CenteringPregnancy* (CP) care model, has been proposed as a method to reduce premature birth through a reduction in maternal stress across the pregnancy through education, and social and emotional support.[71,72] This hypothesis has

been supported by some observational data that link CP to fewer feelings of being alone,[73] higher satisfaction with care,[71,74–76] and lower risks for postpartum depression.[77] A recent RCT looking at CP[78] found that high-stress women randomly assigned to CP reported significantly increased self-esteem, decreased stress, and social conflict suggesting that CP improves psychosocial outcomes.

CP care model is an innovative, relationship-centered model for PNC which incorporates 3 essential components of prenatal care—*health assessment*, *education*, and *support activities*. Pregnant women are empowered through peer support to participate, learn, make informed decisions, and self-manage their care activities and thereby more frequently resolve or reduce their psychosocial and behavioral pregnancy risks.[79] Groups of up to 8 to 12 pregnant women at approximately the same gestational age meet together for 10 prenatal care visits. Each 2-hour session contains part of an educational curriculum provided through facilitated discussion which includes nutritional counseling, childbirth preparation, stress-reduction techniques, relationship support, and best practices for parenting. An emphasis is placed on relationship building and improved social support for the group members.[80,81]

Centering care, based on the CP model, has been shown to lead to decreased rates of PTB and LBW infants in a majority of studies (Table 2) when compared with routine prenatal care with traditional individual patient per provider interaction. Most studies were performed in public health clinics,[76,82] with Medicaid-eligible[80] or low SES[83] women. Many studies were in settings predominately serving minority patients including African Americans,[71,74,76] Hispanics,[82] or both.[83,85] In addition, CP appears to be effective in high-risk groups such as teenagers[74,89] and the CP model appears effective even after translation into Spanish.[82] Picklesimer et al[80] noted that CP appears to diminish racial and ethnic disparities for PTB and they postulate that outcomes are because of 3 aspects of the intervention: (1) enhanced education empowering women to seek medical attention earlier; (2) better communication leading to improved compliance; and (3) enhanced levels of social support helping low-resource women with stress-coping.

Other types of group care have been examined including group care with peer mentors[86] and group care with care coordination.[65] When teenagers were paired with each other, taught how to perform clinical maneuvers, and provided education about prenatal care and healthy pregnancies there was no difference in the frequency of LBW babies.[86] Participants in the California black infant program, who received 20 group sessions with complementary case management (a program designed to encourage and support a healthy pregnancy), showed no difference in rates of PTB (17.9% vs. 17.9%) or LBW (14.9% vs. 14.1%, $P = 0.61$) when compared with African American nonparticipants.[65] Two RCTs have been performed looking at group PNC to reduce the rates of PTB and LBW babies.[71,87] Icovicks and colleagues performed a multisite RCT at 2 university-affiliated hospital prenatal clinics. A total of 1047 young women (aged 14 to 25 y old) were randomized to standard or CP group care (after excluding women with medical conditions). A majority of the participants (80%) were African American and nulliparous ($\sim$60%). Women receiving care in the CP group were 33% less likely to have PTB compared with standard care (odds ratio = 0.67; 95% CI, 0.32-0.92; $P = 0.02$) with no differences in age, parity, education, or income between study conditions. This effect appeared strengthened for African American women (odds ratio = 0.59; 95% CI, 0.38-0.92; $P = 0.02$). A cluster RCT was performed in Zanjan (a city with a population of around 500,000 in the north-west region of

TABLE 2. Group Prenatal Care and Centering Pregnancy

References	Study Design	Participants	Intervention	Preterm Birth (PTB) Findings	Low Birthweight (LBW) Findings	Conclusions
Tandon et al[82]	Retrospective cohort	Hispanic, low-income women in 2 public health clinics, self-selected. 150 CP, 66 usual care.	CP model for prenatal care	CP group had lower rate of PTB (5% vs. 13%, $P = 0.04$)	CP group had no difference in rate of LBW (5% vs. 7%, $P = 0.52$)	CP appears to reduce frequency of PTB but not LBW
Ickovics et al[83]	Matched cohort study	458 low SES women matched by clinic, age, race, parity, due date	CP model for prenatal care	CP group had no difference in rate of PTB (9.2% vs. 9.6%, $P = 0.83$)	CP group had no difference in rate of LBW (7.0% vs. 10.0%, $P = 0.38$)	NS
Grady et al[74]	Prospective cohort	124 African American teenagers compared with two groups of teens: contemporary and historic control	CP model for prenatal care	CP group had lower rate of PTB compared with contemporary (10.5% vs. 25.7%, $P < 0.02$) and historical controls (10.5% vs. 23.2%, $P < 0.05$)	CP group had fewer LBW babies compared with the contemporary (8.87% vs. 22.9%, $P < 0.02$) and historical controls (8.87% vs. 18.3%, $P < 0.05$)	CP appears to decrease the frequency of PTB and LBW in teens
Klima et al[84]	Observational study	101 Medicaid-eligible women in compared with 207 controls	CP model for prenatal care	CP group had no difference in rate of PTB (13.1% vs. 11%, $P =$ NS)	No data reported	NS
Ickovics et al[71]	RCT	Pregnant women aged 14-25 y (n = 1047) were randomly assigned to either standard or group care	CP model for prenatal care	CP group had lower rate of PTB (9.8% vs. 13.8%, $P = 0.045$). Subgroup of African American women in CP had lower rate or PTB vs. standard care (10.% vs. 15.9%, $P = 0.02$)	CP group showed no difference in LBW babies compared with controls (11.3% vs. 10.7%, $P = 0.90$)	CP frequency of PTB, particularly in African American women but not LBW
Barr et al[85]	Retrospective cohort study	195 women cared for by family medicine residents using the group prenatal care model compared with 184 women previously provided standard PNC	CP model	CP had no difference in PTB rate compared with prior care (4.15% vs. 8.33%, $P = 0.093$). However after adjusting for multiparous and insurance status, CP showed a significant decrease in PTB aOR 0.39 (95% CI, 0.15-0.98; $P = 0.045$)	CP had no difference in LBW rate compared with prior care (4.76% vs. 8.47%, $P = 0.152$), which did not change after adjusting for confounders aOR 0.42 (95% CI, 0.18-1.06; $P = 0.067$).	CP may decrease PTB after adjusting for multiparous and insurance status
Picklesimer et al[80]	Retrospective cohort study	316 low risk self-selected group prenatal care compared with 3767 women in usual care	CP model for prenatal care	CP group had lower rate of PTB (7.9% vs. 12.7%, $P = 0.01$). When adjusted for maternal	CP group showed no difference in LBW babies compared with controls (8.9%	CP reduced frequency of PTB, particularly the racial disparities associated with

TABLE 2. (Continued)

References	Study Design	Participants	Intervention	Preterm Birth (PTB) Findings	Low Birthweight (LBW) Findings	Conclusions
				demographics and adequacy of prenatal care the aOR for PTB in CP group was 0.53 (95% CI, 0.34-0.81)	vs. 11.4%, $P = 0.265$)	PTB, but did not change the frequency of LBW
Ford et al[86]	RCT	282 urban adolescents randomized to group prenatal care vs. traditional care	Teens were placed in groups of 6-8, and partnered with another pregnant teen with a similar due date. Teens were taught to perform clinical measures on each other, and given further education on healthy pregnancy habits and routine pregnancy occurrences.	NA	Group care had nonsignificant decrease in LBW (6.6% vs. 12.5%, $P = 0.08$)	NS
Jafari et al[87]	Cluster RCT	320 in group PNC were compared with 308 women in usual care	Participants were placed in groups of 8-10 women, meeting 10 times during the pregnancy. Sessions were 90-120 min. Sessions focused on education, skills-building specific to PNC, and self-care activities	Group care had no significant difference in rate of PTB compared with usual care (6.3% vs. 9.7%, $P = 0.191$)	Group care had no significant difference in rate of LBW compared with usual care (6.2% vs. 9.1%, $P = 0.213$)	NS
Willis et al[65]	Prospective observational study	1553 women involved in the BIH program compared with 11,633 women not in the BIH program	Women in the BIH program received twenty group sessions (10 prenatally, 10 postpartum) with complementary case management, designed to encourage and support a healthy pregnancy	The PTB rates were the same in both groups (17.9%)	The rate of LBW infants was similar between BIH participants and controls (14.9% vs. 14.1%, OR = 1.07; 95% CI, 0.83-1.38; $P = 0.61$)	Group PNC with case management did not decrease the rates of PTB and LBW infants
Ruiz-Mirazo et al[88]	Systematic review and meta-analysis	3242 women, 8 low-quality studies		Group PNC had lower rates of PTB (RR = 0.71; 95% CI, 0.52-0.98)	No difference between group PNC and usual care for LBW (RR = 0.91; 95% CI, 0.65-1.27)	Group PNC lowers rate of PTB, but no difference in LBW outcomes

BIH indicates black infant health program in California; CP, CenteringPregnancy; LBW, low birthweight (< 2500 g); NA, not applicable; NS, not significant; PNC, prenatal care; PTB, preterm birth (< 37 wk gestational age); RCT, randomized controlled trial; SES, socioeconomic status.

Iran.).[87] Prenatal and postnatal care in this area was provided free of charge by midwives through free public health centers. The health centers in the city were stratified by geographic area and randomized to provide either group or individual prenatal care to their patients. Each prenatal care group consisted of 8 to 10 women meeting 10 times during pregnancy for 90 to 120 minutes. Visits included routine clinical measures and educational group discussions addressing the following themes: (a) prenatal nutrition; (b) common discomforts of pregnancy; (c) caring of mother's health during pregnancy; (d) pregnancy problems; (e) labor and delivery; (f) decisions of pregnancy and developing a birth plan; (g) breastfeeding; (h) postpartum adjustment; (i) new baby care; and (j) medical procedures and tests during pregnancy. There was a nonsignificant reduction in the PTB and LBW rates between group prenatal care and standard PNC (PTB: 6.3% vs. 9.7%, $P = 0.191$; LBW: 6.2% vs. 9.1%, $P = 0.213$).[87] The above 2 RCTs[71,87] were analyzed in a recent meta-analysis along with 4 cohort studies[74,83,84,89] containing 3242 women, group PNC appeared to reduce the rates of PTB (RR = 0.71; 95% CI, 0.52-0.98) but showed no difference in LBW (RR = 0.91; 95% CI, 0.65-1.27).[88] The difference in outcomes in various studies may be due to questions in adherence to the CP model fidelity which has recently been correlated to PTB.[90] There are also concerns from prenatal care providers about the feasibility and sustainability of a group prenatal care model.[84] More research is needed to confirm the relationships between centering pregnancy, maternal stress reduction, and PTB, but the current data support the efficacy of this intervention. Studies have yet to probe the biological mechanisms through which CP reduces PTB and it will be important to examine to what extent CP can affect CRH activity, inflammation, infection, and other candidate pathways.

INCREASED PRENATAL CARE EDUCATION/SUPPORT

As stress has been proposed to contribute to PTB through both physiological and behavioral pathways,[39] interventions have been studied using increased education and social support in the clinical setting (Table 3), through home visitation (Table 4) and telephone interventions (Table 5) to counteract these 2 effects.

In The Clinical Setting

Although 1 study suggested augmentations to prenatal care in the form of added education and counseling in the setting of prenatal care to be promising,[91] several studies have failed to show a change in the frequency of PTB or LBW (Table 3).[92,94–98] An initial study in the late 1970s/early 1980s conducted in Eastern France suggested that using a risk scoring system and targeted activity counseling could decrease the frequency in PTB and LBW.[91] On the basis of the premise that "some exertions connected with daily activities have a triggering effect on PTL" women were given advice on reduction of physical efforts of at-risk women. Over the following decade, there was a sequential decrease in PTB (5.4% vs. 4.1% vs. 3.7%, $P < 0.001$) and LBW (4.6% vs. 4.0% vs. 3.8%, $P < 0.001$) which the authors attribute to the program. However, given the long study period the multiple potential confounders, these results have yet to be substantiated by more rigorous methodology.

Additional social support in the clinical setting has not been linked to decrease in LBW and PTB. Klerman and colleagues looked at augmenting PNC with additional social support including peer groups, additional appointments/time with clinicians, onsite child care, transportation assistance, and further directed counseling. They found no difference in PTB (10.6% vs. 14.0%, $P = 0.22$) or LBW (12.5% vs. 11.2%, $P = 0.60$).[94] Similar results for PTB (6.4% vs. 5%, $P < 0.25$) or spontaneous PTB (5.1% vs. 4.2%, $P < 0.25$) were found in a study

TABLE 3. Increased Prenatal Education/Support in the Clinic

References	Study Design	Participants	Intervention	Preterm Birth (PTB) Findings	Low Birthweight (LBW) Findings	Conclusions
Papiernik et al[91]	Observational study	Single live births over 3 periods of time in homogenous French population (1971-1974, n = 5763), (1975-1978, N = 4957), (1979-1982, N = 5919)	Systematic program to assess risks and education about prevention of PTB through risk assessment, targeted education, and recommendations about reduction of physical efforts for women at risk (including work-leave)	PTB decreased over study periods 5.4%, 4.1%, 3.7% ($P < 0.001$)	LBW decreased over study periods 4.6% vs. 4.0% vs. 3.8% ($P < 0.001$)	This intervention appears to decrease PTB and LBW outcomes; however, observational and many possible unrecognized confounders
Konte et al[92]	Retrospective cohort	7382 births during intervention vs. 1914 preintervention births	Intervention: assess women for risk of PTL, provide education/ training/support for women. Follow-up visits every 1-2 wk	No difference in PTB rate prior (6.4% vs. 5.8%, $P > 0.05$)	NA	NS
Hobel et al[93]	RCT	High-risk patients were identified and randomized to either experimental site (n = 1774) or usual care (n = 880)	Experimental sites had prenatal education and more frequent visits. They were further randomized to receive secondary intervention protocols (bed rest, psychosocial support, and oral progesterone)	Experimental clinics had a lower PTB rate than control (7.4% vs. 9.1%, $P < 0.05$). This finding remained after multivariate logistic regression controlling for high-risk problems and gravidity, aOR = 0.58 (95% CI, 0.58-1.04, $P = 0.045$)	No difference in LBW (5.8% vs. 6.4%, $P = 0.15$)	Extra prenatal education and more frequent visits appeared to reduce PTB rate but not LBW outcomes.
Klerman et al[94]	RCT	318 augmented care, 301 usual care. African American, Medicaid eligible, high risk	Augmented care-oriented peer groups, additional appointments, extended time with clinicians other supports (onsite child care, patient being seen in 5 min of appointment, transportation was provided, extended clinic hours, further directed counseling)	No difference in PTB (10.6% vs. 14.0%, $P = 0.22$)	No difference in LBW 12.5% vs. 11.2% ($P = 0.60$)	NS

TABLE 3. (Continued)

References	Study Design	Participants	Intervention	Preterm Birth (PTB) Findings	Low Birthweight (LBW) Findings	Conclusions
Kiely et al[95]	RCT	1044 women. Washington DC area. Self ID minorities, ≥18 y, <28 wk pregnancy who had at least 1 RF (cigarette smoking, exposure to tobacco smoke, depression, and intimate partner violence)	Intervention was integrated cognitive behavioral intervention	No difference in PTB ($P = 0.135$)	No difference in LBW (P = 0.204) or VLBW ($P = 0.052$)	NS
Subramanian et al[96]	Randomized intervention	Low income, African American, Washington, DC/ metro. ≥18 y (active smoking, environmental smoke, depression, or intimate partner violence)→ randomized to intervention or usual care. (510 intervention, 515 usual care)	Intervention specific to psychosocial and behavioral risks targeted: smoking—elements from Smoking Cessation or Reduction in Pregnancy Program Treatment, "pathway to change"—self-help manual, group CBT adapted for individual delivery, guidance for intimate partner violence intervention. At routine PNC visits, 35-55 min. 8 visits required for total intervention, 4 visits were considered "adequate"	No difference in PTB intervention vs. control (14.5% vs. 14.7%)	No difference in LBW in intervention vs. control (12.8% vs. 13.6%) or VLBW (1.6% vs. 2.2%)	NS
Heins et al[97]	RCT	1458 women at high risk for low birthweight	Intervention was administered by nurse-midwives and included patient education, activity counseling, stress reduction by enhancing social support, nutrition counseling substance abuse counseling	NA	No difference in LBW 19% vs. 20.5% (P = NS)	NS

TABLE 3. (Continued)

References	Study Design	Participants	Intervention	Preterm Birth (PTB) Findings	Low Birthweight (LBW) Findings	Conclusions
Rothberg and Lits[98]	RCT	86 white mothers, singleton pregnancies, and no know obstetric risk factors	The intervention was psychosocial support between enrollment at 20 wk and delivery. Mothers were partnered with one of 2 social workers for an individual, client-centered relationship that helped women deal with stress (eg, in home life, work, or pregnancy related)	NA	No difference in LBW 14.0% vs. 11.6% (P = NS)	NS

LBW indicates low birthweight (< 2500 g); NA, not applicable; NS, not significant; PNC, prenatal care; PTB, preterm birth (< 37 wk gestational age); RCT, randomized controlled trial; SES, socioeconomic status; VLBW, very low birthweight (< 1500 g).

providing further education, training, and support for women in Northern California.[92]

Targeted behavioral therapy counseling in the clinical setting has been examined as a method to reduce indirect effects of stress. Kieley and colleagues performed an RCT with over 1000 minority women with at least one of the following risk factors: cigarette smoking, exposure to tobacco smoke, depression, and intimate partner violence. Cognitive behavioral therapy was provided to mitigate the specific risk factor. There was no difference in PTB (13% vs. 19.7%, $P = 0.135$) or LBW (12.8% vs. 18.5%, $P = 0.204$), but a decrease in PTB < 33 weeks (1.5% vs. 6.6%, $P = 0.030$).[95] In a similar population, a randomized intervention was conducted consisting of 8 visits targeted toward behavioral change during routine PNC visits.[96] Again, there was no difference seen in PTB (14.5% vs. 14.7%) or in LBW (12.8% vs. 13.6%). Although these targeted counseling interventions had other benefits (eg, reduction in domestic violence and increased smoking cessation), there are scant data linking these interventions with prevention of PTB or LBW outcomes.

Other studies looking at patient education, activity counseling, social support, and substance abuse counseling[97] or client-centered psychosocial support[98] as part of routine PNC showed no difference in frequency of LBW. Although increased support in the form of additional resources (eg, transportation or child care) or other forms of support (eg, directed counseling) may help decrease anxiety and have other benefits (possible decreasing prenatal admission and cesarean sections),[110] it does not appear to decrease the frequency of PTB or LBW outcomes.

Through Home Visitation

One of the widest studied models for improving both prenatal outcomes, and infant outcomes through home visitations is the NFP model.[111] NFP is an evidence-based, national health program that partners with local community organizations to optimize providing prevention services

TABLE 4. Increased Education/Support Through Home Visits

References	Study Design	Participants	Intervention	Preterm Birth (PTB) Findings	Findings	Conclusions
Olds et al[99]	RCT	Semirural Appalachian community in New York State primagravid women with at least risk factor for infant health and development	Four treatment groups where each higher numbered group has all interventions of prior group: (1) only screening of child postnatally; (2) transportation to prenatal care visits; (3) nursing home visitation during pregnancy; and (4) visitation in first 2 y of life. The curriculum for nurses consisted of nutritional counseling, enhance informal social support, linked families to community-based services	Women with intervention had outcomes similar to controls with PTB rate of 6.9% vs. 7.3%, P = NS. However differences in PTB rates were significant for smokers (2.1% vs. 9.8%, $P < 0.05$)	Women with intervention had outcomes similar to controls with LBW 5.8% vs. 2.6%, P = NS	Overall NS change in PTB and LBW. However, may show small reduction in PTB in smokers.
Blondel et al[100]	RCT	158 women in Paris with threatened PTL between 26-36 wk	Women were visited once or twice a week where they received routine prenatal care and were encouraged to rest and have their friends or family to help with housework	No difference between PTB in intervention vs. control (18% vs. 15%, P = NS)	NA	NS
Bryce et al[101]	RCT	1970 Australian women with poor obstetric histories; 983 randomly allocated to program group, 987 to control group	Home visits at 4-6 week interval and more frequent phone calls if desired to provide emotional social support by providing sympathy, empathy, understanding, acceptance and affection and attempting to act as a confidante through. Midwives were instructed to encourage women to find their own	Intervention group had a NS lower rate of PTB than control (12.8% vs. 14.9%, OR = 0.84 (95% CI, 0.65-1.09). When PTB was stratified for confounders (such as prior PTB and current multiple gestation) aOR = 0.75 (95% CI, 0.57-0.98)	NA	Overall NS change in PTB. However, when stratified by potential confounders including prior PTB and current multiple gestation ~13% risk reduction for PTB

TABLE 4. (Continued)

References	Study Design	Participants	Intervention	Preterm Birth (PTB) Findings	Findings	Conclusions
			answers first and provide instructional information second			
Villar et al[102]	RCT	4 centers in Latin America, 2235 women at higher than average risk for LBW infant recruited before 20th week. Intervention (n = 1115) or control (N = 1120)	Minimum of 4 home visits by health worker for emotional support, health education, attempt to "enhance the woman's social support". Four main components: reinforcement of social support network, knowledge of pregnancy and delivery, emotional support, reinforcement of adequate health services utilization	Women with intervention had outcomes similar to controls with PTB OR = 0.88 (95% CI, 0.67-1.16)	Women with intervention had outcomes similar to controls with LBW OR = 0.93 (95% CI, 0.68-1.28)	NS
Rogers et al[103]	Retrospective cohort	1901 teenagers in South Carolina; comparison group from counties where program not offered (N = 4613)	The intervention consisted of using resource mothers (RMP) to give social support and education through monthly home visitation in addition to helping the teenager access the health care system. Resource mothers consisted of paraprofessional women who received 3 wk of training	RMP group had same frequency of PTB as control (19.0% vs. 18.3%, $P = 0.64$). However, after controlling for confounders (age, marital status, race, prior pregnancy) significant difference in PTB in RMP group for unmarried teenagers aOR = 0.81 (95% CI, 0.70-0.95) but not for married teenagers aOR = 1.22 (95% CI, 0.87-1.73)	RMP group had same frequency of LBW as control (11.6% vs. 10.8%, $P = 0.39$) NS even after controlling for confounders	Overall NS change in PTB and LBW. However, may show small reduction in PTB in unmarried teenagers
Kitzman et al[104]	RCT	1139 primarily African American women at < 29 wk gestation and at least 2	Nurses made an average of 7 (range, 0-18) home visits during pregnancy and average of 26	No difference between intervention and control (13% vs. 11%, OR = 0.8; 95% CI, 0.6-1.2)	No difference between intervention and control (14% vs. 15%,	NS

TABLE 4. (Continued)

References	Study Design	Participants	Intervention	Preterm Birth (PTB) Findings	Findings	Conclusions
		sociodemographic risk characteristics (unmarried, < 12 y of education, unemployed) in Memphis, TN	(0-71) home visits from birth to the child's second birthday		OR = 1.1; 95% CI, 0.8-1.6)	
Brooten et al[105]	RCT	173 (194 infants) women with high-risk pregnancies randomly assigned to intervention group (85 women and 94 infants) or the control group (88 women and 100 infants) (24 twins in control and 18 twins intervention)	Women received half of their prenatal care in their homes, with teaching, counseling, telephone outreach, daily telephone availability, and a postpartum home visit by nurse specialists with physician backup	Intervention group had a decreased rate of PTB compared with control (30.9% vs. 40.8%, $P < 0.01$). Twins delivered from the intervention group had a decreased rate of PTB compared with control (22.2% vs. 66.7%, $P < 0.01$)	Intervention group had same rate of LBW compared with control (35.7% vs. 34.0%, P = NS)	Intervention appears to decrease PTB rate, but does not appear to affect LBW
McLaughlin et al[106]	RCT	428 women at a public hospital in Nashville	Women were randomly place in the standard care or comprehensive care group. The comprehensive care group received prenatal care provided by a multidisciplinary team of nurses-midwives, social workers, nutritionists, etc. Team focused on psychosocial support for women as well as education about self-care and health behaviors. Missed appointments followed by phone calls/ mailings/home visits	NA	Women receiving intervention had no difference in LBW infants (10% vs. 9%, $P = 0.20$)	NS
Norbeck et al[107]	RCT	114 "low-support" African Americans in CA Intervention: 56, control:58	Four face-to-face sessions in woman's home with script: first; validation of women's life situation looking at 3 problem areas and 3 successful areas:	NA	Women receiving intervention had significantly fewer LBW infants (9.1% vs. 22.4%, $P < 0.05$).	Home counseling sessions appeared to decrease the rate of LBW infants in this patient population.

TABLE 4. (Continued)

References	Study Design	Participants	Intervention	Preterm Birth (PTB) Findings	Findings	Conclusions
			second; meaning of pregnancy to participant: third; and fourth: focused on self-esteem and healthy relationships			

LBW, low birthweight (< 2500 g); NA, not applicable; NS, not significant; PNC, prenatal care; PTB indicate preterm birth (< 37 wk gestational age); RCT, randomized controlled trial; SES, socioeconomic status; VLBW, very low birthweight (< 1500 g).

to low-income families. One-on-one home visits between low-income, first-time mothers, and specially trained nurses start before the 28th week of pregnancy and continue through the child's second birthday. Sessions focus on self-efficacy, human ecology, and attachment theory and tailoring the care to the strengths and challenges of each family. One of the goals of the NFP is to improve pregnancy outcomes by helping women engage getting prenatal care from their health care providers, improving their diet, and reducing their use of cigarettes, alcohol, and illegal substances. Although the program shows many benefits for the health of the mother and the child, only 2 studies looked at PTB or LBW,[99,104] and only one of the 2 found a reduction in PTB with the intervention.[99]

Other studies looking at home visits to provide emotional support, education, and counseling appear promising (Table 4). Interventions looking at PNC either provided in part in the home[105] or augmented by additional support and education in the home setting[99,101,103] may reduce PTB in certain subsets of the population after controlling for confounders. A RCT where half of a high-risk patient's PNC was provided at home in addition to teaching, counseling, and telephone availability showed an ~25% reduction in overall frequency of PTB (30.9% vs. 40.8%, $P < 0.01$) with an even larger reduction twin PTB (22.2% vs. 66.7%, $P < 0.01$).[105] When Olds et al[99] studied varying levels of additional home care in a RCT, used to develop the NFP model, they did not find an overall reduction in PTB (6.9% vs. 7.3%, NS). However, they did find a reduction in PTB for smokers (2.1% vs. 9.8%, $P < 0.05$). In Australian women with poor obstetrics histories, home visits providing sympathy, empathy, understanding, acceptance, and affection showed decreased frequency of PTB when stratified for confounders.[101] In addition, in a retrospective cohort looking at resource mothers (trained paraprofessional women) to provide monthly home social support and education to teenagers in South Carolina found a decrease in PTB for unmarried teenagers after controlling for confounders (age, race, marital status, and prior pregnancy).[103]

Three other RCTs looking at home visitation found no decrease in the frequency of PTB.[100,102,104] One was an attempt to coordinate a large, multicountry trial in South America by providing 4 home visits to participants.[102] A second, looking at NFP model, had a primary outcome of reduction of pregnancy-induced hypertension and childhood injuries and ingestions.[104] The third RCT was conducted in Paris in women who had threatened PTL between 26 and 36 weeks' gestational age.[100] Although these studies

TABLE 5. Increased Education/Support Through Telephone Calls

Authors	Study Design	Participants	Intervention	Preterm Birth (PTB) Findings	Low Birthweight (LBW) Findings	Conclusions
Boehm et al[108]	Prospective cohort	64 high risk for preterm delivery: control group (n = 21), study group (n = 21), other (n = 22)	The intervention was a daily telephone call consisted of a 7-question structured interview related to feelings of well-being, signs/symptoms of PTL, any other unusual symptoms/problems, and compliance with tocolytic therapy (if applicable). All groups had education, the control, and study groups had education, more frequent visits, and cervical examinations. The other group received education but refused to participate	No difference in PTB between groups (42.9% vs. 42.9% vs. 31.8%, $P = 0.69$)	NA	NS
Moore et al[109]	RCT	1554 women who met inclusion criteria (black women, white/other race women with labor risk score of 7)	Instructions about the signs of preterm labor, schedule for time, and frequency of telephone calls, contact for nurse. 3 calls/week, 3 main areas: perception of uterine contractions or other pregnancy changes, color of urine as assessment of hydration, number of meals eaten, number of cigarettes smoked, alcohol/drug use, ingestion of PNV prior day)	Intervention vs. control: black women: (9.4% vs. 12.8%, $P = 0.64$). Age ≤ 18: (11.0% vs. 7.9, $P = 0.039$). Age ≥ 19: (8.7% vs. 15.4%, $P = 0.004$). White women/other: (11.2% vs. 5.0%, $P = 0.044$). Age ≤ 18: (7.8% vs. 4.1%, $P = 0.255$). Age ≥ 19 (19.6% vs. 6.6%, $P = 0.041$)	Intervention vs. control: black women: (11.3% vs. 15.3%, $P = 0.47$). Age ≤ 18: (11.0% vs. 11.6%, $P = 0.874$). Age ≥ 19: (11.4% vs. 17.3%, $P = 0.064$). White women/other: (9.9% vs. 10.0%, $P = 0.879$). Age ≤ 18: (7.0% vs. 6.1%, $P = 0.807$). Age ≥ 19: (19.6% vs. 6.6%, $P = 0.041$)	NS overall. Perhaps a reduction in PTB for black women ≥ 19. Possible harm of intervention to white women ≥ 19 (authors attribute to tobacco use)

LBW indicates low birthweight (< 2500 g); NA, not applicable; NS, not significant; PNC, prenatal care; PTB, preterm birth (< 37 wk gestational age); RCT, randomized controlled trial; SES, socioeconomic status; VLBW, very low birthweight (< 1500 g).

are well designed, it is unclear if the home visitation interventions were specifically designed to target PTB,[102,104] or provide additional psychosocial support beyond close assessment of PTL symptoms.[100]

Home visitation as a method to reduce LBW infants has mixed findings. A RCT of women in England with a history of LBW babies in a socially disadvantaged/working class group were shown to have

an increase in mean birthweight by approximately 40 g with social support intervention through 24-hour availability of midwives, and home visits to address concerns, give advice, and provide referrals to health care/social welfare agencies.[37] Although this finding is statistically significant, clinical significance is unclear. Likewise, when Norbeck et al[107] targeted low-support African Americans and provided 4 face-to-face counseling sessions directed toward problem solving and fostering empowerment, they found a decrease in the frequency of LBW (9.1% vs. 22.4%, $P < 0.05$). However, a RCT performed in Nashville looking at comprehensive care including home visitation did not find a significant decrease in the frequency of LBW (10% vs. 9%, $P = 0.20$).[106] Several other studies did not find that home visits improved LBW outcomes.[99,102–105] The evidence suggests that targeted home visitation may decrease the frequency of PTB and LBW in certain populations (tobacco users, unmarried teenagers, low-support African American women); however, more research is needed.

Through Telephone Calls

Studies on telephone intervention for the prevention of PTB have been performed and generally showed no difference in rates of pregnancy complications (Table 5). Boehm et al[108] performed a prospective study where participants received a daily phone call from a nurse. Despite this intensive intervention, there were no differences in PTB between the women with the daily telephone intervention compared with either the control group or the nonparticipant group (42.9% vs. 42.9% vs. 31.8%, $P = 0.69$). This study was likely underpowered and had a heterogeneous mix of patients with different racial backgrounds and SES.[108] A more recent study did not show an overall significant reduction in PTB (9.7% vs. 11.0%, $P = 0.415$) or LBW (10.9% vs. 14.0%, $P = 0.072$). However, in the subgroup of black women over 18 years there was a 44% decrease in PTB (8.7% vs. 15.4%, $P = 0.04$) and a 34% decrease in LBW (11.4% vs. 17.3%, $P = 0.02$) with the intervention. Interestingly, white women over 18 years of age in the intervention had a higher rate of PTB than controls (19.6% vs. 6.6%, $P = 0.041$), which the authors attributed to increased tobacco use in the intervention group at baseline.[109] In addition, these data were reviewed from a cost-benefit perspective and it was calculated that spending $117 per pregnancy would provide approximately $17,000 in economic benefit.[112]

Studies looking at increased education and social support show mixed results when applied to patients seen in the clinic setting, at home or over the telephone. A recent meta-analysis looked at providing "additional support" for women at-risk for PTB or LBW[110] and found no difference in the risk of PTB (RR = 0.92; 95% CI, 0.83-1.01) or LBW (RR = 0.92; 95% CI, 0.83-1.03). Although augmenting prenatal care in the clinic setting showed benefits in other areas, there was no clear difference in the rate of PTB or LBW infants. Increased education and social support through home visitation appears to be beneficial to certain groups (eg, high-risk patients, smokers, unmarried teenagers). Likewise, additional telephonic support appeared to be beneficial for a subgroup of patients (black women over 18). However, more research is needed in the efficacy of these interventions.

EXPANSION OF PUBLIC HEALTH INSURANCE

Expanding medical coverage is likely to include aspects of other interventions, such as increased care coordination or home visits. A recent study found that increased availability of government-sponsored insurance decreased symptoms of depression and decreased the financial strain of participants.[113] However, there are few studies that focus exclusively on PTB outcomes as a result of increased government-supported prenatal care. A study looking at the New York State

Prenatal Care Assistance Program focused on Medicaid-sponsored expansion, and its effect on birth outcomes in New York City. Women in the program had infants that weighed around 50 g more, and had rates of LBW 2.5% less than infants not enrolled (eliminating preterm infants, the improvements associated with Prenatal Care Assistance Program would be 35 g in birthweight and 1.3% in rates of LBW).[114] Another study that examined Medicaid-sponsored enhanced prenatal care service was done by Baldwin et al[115] in Washington state. The effects of Medicaid expansion on Washington's LBW rates were compared with the LBW rates in Colorado, a control state that did not enhance prenatal care services. Although there was an overall decrease in the state's LBW rate (7.1% to 6.4%, $P = 0.12$), the improvement was most significantly noted in medically high-risk women (adults: 18% to 13.7%, $P = 0.01$, teens; 22.5% to 11.5%, $P = 0.03$). Colorado's LBW rate increased slightly during this time period.[115] A similar evaluation of California's statewide implementation of enhanced perinatal services funded by Medicaid found no significant difference in LBW rate.[116] In a countrywide program implemented in Martinique, no significant difference in outcomes was found between women who received care free government prenatal care and those who received private care from obstetricians.[117]

In studies that observe the outcomes of large coverage programs, there are myriad potential reasons for the outcomes. It is also difficult to pinpoint which aspect of the expanded services was associated with the improvements. Although reduction in stress due to decreased financial strain and further access to care may be a component, it likely does not account for a majority of the findings.

TEACHING STRESS-REDUCTION STRATEGIES

There have been other interventions looking at stress reduction during pregnancy including one-on-one stress-reduction sessions,[118] applied relaxation,[119] targeted cognitive behavioral counseling[95,96] mindfulness interventions including yoga[120–122] and aquatic exercise.[123] However, there have been few studies that correlate stress-reduction interventions with PTB or LBW outcomes.[95,96,118,119,122]

Studies looking at one-on-one stress-reduction sessions or training in applied relaxation have not consistently shown reductions in PTB and LBW outcomes. A one-on-one stress-reduction session along with encouraging deep breathing and guided imagery via audiotape 3 times a week was shown to decrease maternal stress on the perceived stress scale, and increase mean birthweight and gestational age versus controls.[118] An RCT performed in Iran with low-risk anxious primigravid women showed a reduction in LBW (5.8% vs. 26.9%, $P = 0.003$) but not PTB (1.9% vs. 9.8%, $P = 0.102$) when participants were given 7 weeks of applied relaxation training sessions.[119]

Mindfulness practices and yoga have been studied as methods of preventing stress during pregnancy.[120,121] Bedoe and Lee systematically reviewed studies of mid-body interventions during pregnancy. While they found several methodological problems, mainly due to the absence of a randomized control group, or controlling to confounders they noted that treatment groups had higher birthweights and reduced percieved stress and anxiety.[120] In a small study, lyengar yoga and mindful-based stress reduction was shown to have decrease in second and third trimester pain and perceived sterss and trait anxiety.[121] There is 1 prospective observational matched study performed in India where women were either recommended to perform yoga practices including posture, breathing, and meditation for 1 hour a day (N = 169) or walk 30 minutes twice a day (N = 166).[122] There was a signficant reduction in PTB (14% vs 29%, $P = 0.0006$) and LBW (19% vs

31%, $P = 0.01$). Although these results appear encouraging, there were some limitations of the study including significant differences between the groups (women who lived closer to the hospital were placed in the yoga group) and other risk factors for PTB (eg, prior PTB) were not addressed. Further research is needed to see if mindfullness practices or yoga can reduce PTB or LBW outcomes.

Conclusions

Chronic stress contributes to PTB, through direct physiological mechanisms or behavioral pathways. This review identified interventions to prevent PTB through decreased maternal stress. Studies were grouped according to intervention: group prenatal care (11 studies), care coordination (8 studies), health insurance expansion (4 studies), expanded prenatal education/support in the clinic (8 studies) home visitation (9 studies), telephone contact (2 studies), or stress-reduction strategies (5 studies).

The current literature published on stress reduction through education, additional social support, and/or coping skills/mindfulness interventions is heterogeneous and mixed in the findings associated with PTB and LBW outcomes. The results of studies looking at care coordination or case management suggest that it may be beneficial to reduce PTB and LBW rates particularly in minority groups. Increased education and social support in the clinic setting does not appear to affect PTB or LBW, but this same type of intervention administered through home visitation appears to be beneficial to certain groups (eg, high-risk patients, smokers, unmarried teenagers). Likewise, additional telephonic support appeared to be beneficial for a subgroup of patients (black women over 18). When looking at expanded public health coverage programs, the results are mixed and it is hard to tease out which aspect of the expanded services was associated with the improvements. Other stress-reduction strategies such as applied relaxation, cognitive behavioral therapy, and mindfulness interventions including yoga appear to reduce stress during pregnancy, but more research is needed in the efficacy of these interventions. It is unclear that specific interventions decrease the rate of PTB and LBW outcomes for all low-risk women, but may show increased benefit for specific groups (eg, teenagers, low-support women, or racial minorities).

Group prenatal care was found to be the intervention with the most evidence showing an association with PTB and LBW prevention. CP has been shown to decrease self-reported maternal stress, most likely through increased maternal support, empowerment, and education in the group setting.[78] When Ickovics and colleagues looked at CP to reduce psychosocial risk, they found significant increases in self-esteem, decreased stress, and social conflict during the third trimester of pregnancy. The consistent, positive findings of the CP model suggest that it is not just the increased education and time spent providing prenatal care that effects the improved outcomes (which alone did not show conclusive results), but the reduction in maternal psychosocial stress through social support and self-efficacy training.

Given the heterogeneity of results, further research is needed to assess the efficacy of interventions designed to prevent PTB through reduction in maternal stress. Research is needed to better understand the components of CP that are contributing to improved pregnancy outcomes, and the underlying changes in behavioral and biological processes that are serving as mechanisms of action. Larger, randomized comparative studies of PTB prevention through different models of prenatal care, different models providing prenatal maternal support, education, and empowerment as well as studies directly targeting

specific maternal stress-reduction and coping strategies are needed. Future work should evaluate these interventions in both low-risk and high-risk women to better understand the populations most likely to benefit from these interventions and the long-term cost-effectiveness of these strategies. PTB rates for the United States have decreased slightly; however, disparities in PTB rates are not improving. The identification and testing of interventions that may effectively reduce risk of PTB in higher risk populations remains a public health imperative.

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