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ORIGINAL ARTICLE

Cumulative psychosocial stress, coping resources, and preterm birth

Sheila W. McDonald · Dawn Kingston · Hamideh Bayrampour · Siobhan M. Dolan · Suzanne C. Tough

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Abstract Preterm birth constitutes a significant international public health issue, with implications for child and family well-being. High levels of psychosocial stress and negative affect before and during pregnancy are contributing factors to shortened gestation and preterm birth. We developed a cumulative psychosocial stress variable and examined its association with early delivery controlling for known preterm birth risk factors and confounding environmental variables. We further examined this association among subgroups of women with different levels of coping resources. Utilizing the All Our Babies (AOB) study, an ongoing prospective pregnancy cohort study in Alberta, Canada (n=3,021), multinomial logistic regression was adopted to examine the independent effect of cumulative psychosocial stress and preterm birth subgroups compared to term births. Stratified analyses according to categories of perceived social support and optimism were undertaken to examine differential effects among subgroups of women. Cumulative psychosocial stress was a statistically significant risk factor for late preterm birth (OR=1.73; 95 % CI=1.07, 2.81), but not for early preterm birth (OR=2.44; 95 % CI=0.95, 6.32), controlling for income, history of preterm birth, pregnancy complications, reproductive history, and smoking in pregnancy. Stratified analyses showed that cumulative psychosocial stress was a significant risk factor for preterm birth at <37 weeks gestation for women with low levels of social support (OR=2.09; 95 % CI=1.07, 4.07) or optimism (OR=1.87; 95 % CI=1.04, 3.37). Our analyses suggest that early vulnerability combined with current anxiety symptoms in pregnancy confers risk for preterm birth. Coping resources may mitigate the effect of cumulative psychosocial stress on the risk for early delivery.

Keywords Preterm birth · Life course · Anxiety · Psychosocial stress

S. W. McDonald · H. Bayrampour · S. C. Tough
Department of Paediatrics, University of Calgary, Calgary, AB, Canada

H. Bayrampour
e-mail: hamideh.bayrampour@albertahealthservices.ca

S. C. Tough
e-mail: suzanne.tough@albertahealthservices.ca

D. Kingston
Faculty of Nursing, University of Alberta, Edmonton, AB, Canada
e-mail: dawn.kingston@ualberta.ca

S. M. Dolan
Department of Obstetrics and Gynecology and Women's Health, Albert Einstein College of Medicine of Yeshiva University, Bronx, NY, USA
e-mail: siobhanmdolan@yahoo.com

S. C. Tough
Department of Community Health Sciences, University of Calgary, Calgary, AB, Canada

S. W. McDonald (✉)
Child Development Centre, University of Calgary, c/o 2888 Shaganappi Trail NW, Calgary, Alberta T3B 6A8, Canada
e-mail: sheilaW.McDonald@albertahealthservices.ca

Introduction

Preterm birth is a major cause of neonatal death and contributes significantly to newborn morbidity including neonatal care complications, cerebral palsy, cognitive impairment, blindness, deafness, and respiratory illness (Hack and Fanaroff 1999; Marlow et al. 2005; Ward and Beachy 2003; Kramer et al. 2000; McCormick et al. 2011; Allen 2008). Impacting approximately 9.6 % of pregnancies worldwide (Beck et al. 2010), preterm birth constitutes a significant international public health issue, with implications for child and family well-being across the life course (Saigal and Doyle 2008; Doyle and Anderson 2010; McCormick et al. 2011;

Petrou et al. 2001). Although conventionally defined as birth before 37 weeks gestation, subgroups of preterm birth include early preterm births (<34 weeks) and late preterm births (34–36 weeks), with the latter constituting the largest and fastest growing subgroup of the preterm population (Davidoff et al. 2006; Martin et al. 2009). In Canada and the USA, preterm birth remains a prominent maternal-child health concern (Goldenberg et al. 2008; Kramer et al. 2000; McCormick et al. 2011) . Although vastly decreased mortality rates in recent decades have led to a greater emphasis being placed on reducing morbidity and optimizing perinatal and early childhood outcomes among longer-term survivors, inquiry into the causes of preterm birth remains a pressing issue. This line of investigation, however, has not yet culminated in a comprehensive understanding and identification of modifiable risk factors and preventive measures for preterm birth (Berkowitz and Papiernik 1993; Adams 1995; Kramer 1987).

Increasing attention has been paid to the role of psychosocial factors in the etiology of preterm birth, including experiences and adaptations during pregnancy such as stressful events, perceived stress, anxiety, and depressive symptoms as well as life course factors such as early adversity and cumulative stress (Dunkel-Schetter and Glynn 2011; Dole et al. 2003; Hedegaard et al. 1993; Copper et al. 1996; Glynn et al. 2008; Nordentoft et al. 1996; Orr et al. 2007). Accumulating evidence suggests that high levels of psychosocial stress and negative affect before and during pregnancy are contributing factors to shortened gestation and preterm birth (Dunkel Schetter 2011; Alder et al. 2007; Wadhwa et al. 2011) as well as other adverse perinatal outcomes (Littleton et al. 2010). The most robust and consistently reported effects on gestational length have been found for pregnancy-specific anxiety (Dunkel-Schetter and Glynn 2011; Dunkel Schetter 2011; Lobel et al. 2008; Alderdice et al. 2012; Kramer et al. 2009); however, this construct has yet to be fully explored (Dunkel-Schetter and Glynn 2011). Less consistent evidence is seen for negative affective states during pregnancy, such as depression (Dole et al. 2003) and general anxiety (Roesch et al. 2004). Although a few studies have reported significant associations between state anxiety and preterm birth (Dunkel-Schetter and Glynn 2011; Paarlberg et al. 1995), many others have not (Dunkel-Schetter and Glynn 2011; Paarlberg et al. 1995); null findings are even more notable for associations between depressed mood and length of gestation (Dunkel Schetter and Tanner 2012). In contrast, depression appears to play an important role in predicting fetal growth and low birth weight, compared to preterm birth (Goedhart et al. 2010).

There is a call for further research regarding combinations of symptoms (i.e., depression and anxiety) (Ibanez et al. 2012) and various forms of stress, including chronic stressors, major life events, and daily hassles/perceived stress on the risk for poor birth outcomes, including preterm birth (Dunkel Schetter and Tanner 2012). Understanding chronic stress as accumulation of stress over time, "life course of events," or allostatic load is particularly useful, providing a new conceptualization of the cumulative biologic burden leading to preterm birth—not unlike biological pathways linking accumulation of stress to other complex diseases such as coronary artery disease and diabetes (Hobel 2004; Tiedje 2003). Most of the extant literature on the effects of psychosocial factors has used the standard definition of preterm birth (i.e., <37 weeks gestational age) (Dunkel-Schetter and Glynn 2011), with only a few studies examining the range of gestational length (Catov et al. 2010; Tegethoff et al. 2010); however, to our knowledge, none have examined the association between psychosocial risk and subgroups of preterm births such as early preterm and late preterm births. Given the accumulation of evidence implicating unique biological and clinical risk profiles for different preterm birth subgroups (Kramer et al. 2000; Engle et al. 2007), exploring whether this extends to include psychosocial factors is a worthy line of investigation.

The objectives of the present study were to: (1) develop a cumulative psychosocial stress variable using a life course approach, which incorporates anxiety symptomatology during pregnancy, feelings about the current pregnancy, and preexisting vulnerabilities; (2) examine the independent effect of the cumulative psychosocial stress variable on the risk of delivering before $34^{0/7}$ weeks gestational age or between $34^{0/7}$ and $36^{6/7}$ weeks gestational age, compared to at least $37^{0/7}$ weeks, while controlling for a number of known risk factors for preterm birth and confounding environmental factors, including prenatal perceived stress; and (3) examine the association between cumulative psychosocial stress and preterm birth among subgroups of women according to low, medium, and high levels of perceived social support and optimism.

Methods

The All Our Babies (AOB) study is an ongoing prospective pregnancy cohort study in Alberta, Canada, that began in 2008. The objectives of the AOB study were to examine maternal well-being and health service utilization across the perinatal period as well as risk and protective factors for adverse birth events and trajectories of child development. Participants completed three questionnaires, twice during the prenatal period (<25 weeks and 34–36 weeks) and once during the postpartum period (4 months). At recruitment, 4,003 women were deemed eligible for study inclusion. In total, 3,388 women participated in the AOB study and completed at least one of the first three questionnaires (84 % participation rate). Specifically, 3,363 women completed the first questionnaire; 3,184 completed the second questionnaire; and 3,058 completed the third questionnaire, for a retention

rate of 91 % at 4 months postpartum. The cohort is being followed annually at 1, 2, and 3 years postpartum. Approximately 85 % of all participants provided consent for medical record linkage, which provides additional and pertinent details on pregnancy complications and birth outcomes not captured on the surveys. Extensive demographic, mental health, lifestyle, and health service utilization data were obtained on each woman, using standardized tools and investigator-/stakeholder-driven items. Information on recruitment, data collection, and questionnaires utilized in the AOB study is described in detail elsewhere (McDonald et al. 2013; Gracie et al. 2010). The final analytic sample (n=3,021) included those who completed the third questionnaire, as this questionnaire collected information on gestational age at birth and was restricted to singleton births. Ethical approval for this study was obtained by the Conjoint Health Research Ethics Board of the University of Calgary. Participants provided informed consent at the time of recruitment and were provided copies for their records.

Study variables

In the present study, cumulative psychosocial stress was operationalized as the combined effect of excessive symptoms of state anxiety at the <25-week data collection time point and at least one of the following: (1) history of a mental health problem (anxiety disorder or depression), (2) history of abuse (physical, sexual, emotional, or neglect), or (3) negative feelings regarding timing of the pregnancy (did not want to be pregnant at this or any other time). The cumulative risk variable was developed to align with a life course and allostatic load approach (Hobel 2004). State anxiety was measured using the Spielberger State Anxiety Index (Spielberger 1989), a standardized tool composed of 20 items that assess current anxiety symptoms. We used an established cutoff of 40 or more to classify women as manifesting a high level of state anxiety symptoms (Spielberger 1989). Maternal history of mental health problems, abuse, and feelings about the timing of the current pregnancy were assessed using single-item questions. The main outcome in this study was gestational age categorized into three groups: early preterm births (<34 weeks), late preterm births (34–$36^{6/7}$ weeks), and term births (≥37 weeks) according to maternal self-report. A previous validation work using AOB data found high agreement between maternal self-report and electronic medical record gestational age groupings (Bat-Erdene et al. 2013). Known risk factors for preterm birth that were controlled for in the present study included demographic (maternal age, education, income, ethnicity), obstetric (personal or family history of preterm birth, reproductive history, mode of conception), medical (pregnancy complications), lifestyle (smoking in pregnancy, prepregnancy BMI, poor prenatal care), and other psychosocial (prenatal perceived stress) factors. Poor reproductive history was defined as a previous miscarriage or stillbirth. Pregnancy complications included the presence of either preeclampsia or gestational diabetes. Prenatal perceived stress was measured using the ten-item Perceived Stress Scale (Cohen et al. 1983), designed to measure stress appraisal in a global sense. Perceived social support and dispositional optimism, assessed using the Medical Outcomes Study Social Support scale (Sherbourne and Stewart 1991) and the Life Orientation Test-Revised scale (Scheier et al. 1994), respectively, were examined as effect modifiers. High social support and high optimism were defined as scores above the 75th percentile of the distribution, while scores below the 25th percentile of the distribution reflected low levels for each construct. Medium levels of social support and optimism comprised scores between the 25th and 75th percentiles, inclusive. With the exception of pregnancy complications, which was taken from the electronic medical record data, all covariates and effect modifiers were drawn from the survey data.

Analysis

Descriptive statistics and chi-square analysis were used to assess associations between gestational age categories and the main predictor variable of cumulative psychosocial stress and covariates. Multinomial logistic regression was used to examine the independent effect of cumulative psychosocial stress and preterm birth subgroups compared to term births, controlling for known risk factors for preterm birth. Stratified regression models were used to examine this association among subgroups of women, with high/medium/low social support and high/medium/low optimism as the stratification variables.

A hierarchal model building strategy was adopted for the multinomial regression analysis, with non-modifiable (e.g., demographic) and previously identified obstetrical, medical, and lifestyle risk factors entered in sequential blocks. Cumulative psychosocial stress was entered at the final step. Given that a number of previous studies have focused on stress, further model building included checking the independent effects of prenatal perceived stress and those factors previously removed at each step to ensure robustness of the final multinomial regression model. The final multinomial model contains important risk factors for preterm birth previously identified in the literature and confirmed by content experts in the field (history of preterm birth, smoking in pregnancy, pregnancy complications) and those factors with significant likelihood ratio tests. Those factors retained in the final multinomial regression model were examined in stratified analyses using binary logistic regression. Odds ratios and 95 % confidence intervals are presented for all final models.

Results

Tables 1 and 2 presents the characteristics of the study sample as well as comparisons between gestational age subgroups by

Table 1 Sample characteristics by gestational age group

Characteristic	Total sample (n=3,021) n (%)	Early preterms (n=38) n (%)	Late preterms (n=173) n (%)	Terms[a] (n=2,784) n (%)	p value
Demographics					
Maternal age					0.970
<35 years	2,261 (77.3)	30 (78.9)	129 (77.2)	2,102 (77.3)	
≥35 years old or more	665 (22.7)	8 (21.1)	38 (22.8)	619 (22.7)	
Education					0.468
Less than postsecondary	697 (23.4)	12 (31.6)	38 (22.4)	647 (23.4)	
Completed postsecondary	2,276 (76.6)	26 (68.4)	132 (77.6)	2,118 (76.6)	
Household income					0.003
<$80,000	826 (28.7)	17 (48.6)	59 (35.8)	750 (28.0)	
≥$80,000 or more	2,057 (71.3)	18 (51.4)	106 (64.2)	1,933 (72.0)	
Ethnicity					0.004
White/Caucasian	2,373 (79.9)	28 (73.7)	119 (70.4)	2,226 (80.5)	
Other	598 (20.1)	10 (26.3)	50 (29.6)	538 (19.5)	
Obstetrics					
Parity					0.083
No previous births	1,452 (49.1)	24 (63.2)	90 (54.2)	1,338 (48.6)	
At least one previous birth	1,503 (50.9)	14 (36.8)	76 (45.8)	1,413 (51.4)	
Poor reproductive history					0.008
Yes (previously pregnant)	712 (23.9)	12 (31.6)	52 (30.8)	648 (23.4)	
No (previously pregnant)	1,204 (40.5)	8 (21.1)	53(31.4)	1,143 (41.3)	
No (not previously pregnant)	1,058 (35.6)	18 (47.4)	64 (37.9)	976 (35.3)	
History of preterm birth					0.003
Yes	604 (20.3)	10 (26.3)	51 (30.0)	543 (19.7)	
No	2,366 (79.7)	28 (73.7)	119 (70.0)	2,219 (80.3)	
Assisted conception					0.003
Yes	206 (6.9)	8 (21.1)	12 (7.1)	186 (6.7)	
No	2,764 (93.1)	30 (78.9)	158 (92.9)	2,576 (93.3)	
Medical					
Pregnancy complications					<0.001
Yes	275 (10.4)	3 (8.8)	35 (22.0)	237 (9.7)	
No	2,369 (89.6)	31 (91.2)	124 (78.0)	2,214 (90.3)	
Lifestyle					
Smoking in pregnancy					0.070
Yes	297 (10.9)	6 (18.8)	23 (15.2)	268 (10.5)	
No	2,433 (89.1)	26 (81.3)	128 (84.8)	2,279 (89.5)	
Prepregnancy BMI					0.806
Overweight	972 (33.3)	15 (40.5)	60 (35.9)	897 (33.1)	
Underweight	131 (4.5)	1 (2.7)	7 (4.2)	123 (4.5)	
Normal	1,813 (62.2)	21 (56.8)	100 (59.9)	1,692 (62.4)	
First prenatal visit within first trimester					0.286
Yes	2,531 (89.3)	36 (94.7)	149 (92.0)	2,346 (89.1)	
No	302 (10.7)	2 (5.3)	13 (8.0)	287 (10.9)	

[a] Due to missing data, the sample size across gestational age subgroups is less than n=3,021

demographic, obstetrical, medical, lifestyle, and psychosocial factors. The majority of the sample were younger than 35 years of age (77 %), had completed postsecondary education (77 %), reported an annual household income of at least $80,000 Canadian dollars (71 %), and were Caucasian (80 %). These characteristics align with the pregnant and parenting population of an urban center in Canada (McDonald et al. 2013). The overall preterm birth rate in the sample was 7 % (n=211), of which 82 % were late preterm. Women who delivered before 37 weeks were significantly

Table 2 Sample psychosocial characteristics by gestational age group

Characteristic	Total sample (n=3,021) n (%)	Early preterms (n=38) n (%)	Late preterms (n=173) n (%)	Terms[a] (n=2,784) n (%)	p value
Psychosocial					
Cumulative psychosocial stress					0.010
Yes	320 (11.0)	7 (18.4)	28 (17.2)	285 (10.5)	
No	2,602 (89.0)	31 (81.6)	135 (82.8)	2,436 (89.5)	
Previous psychosocial stress[b]					0.214
Yes	1,399 (47.9)	15 (41.7)	88 (54.0)	1,296 (47.6)	
No	1,523 (52.1)	21 (58.3)	75 (46.0)	1,427 (52.4)	
History of poor mental health					0.861
Yes	1,002 (33.7)	14 (36.8)	59 (34.9)	929 (33.6)	
No	1,972 (66.3)	24 (63.2)	110 (65.1)	1,838 (66.4)	
History of abuse					0.273
Yes	767 (26.4)	6 (17.6)	49 (30.2)	712 (26.3)	
No	2,139 (73.6)	28 (82.4)	113 (69.8)	1,998 (73.7)	
Negative feelings about current pregnancy					0.009[c]
Yes	74 (2.5)	0 (0)	10 (5.9)	64 (2.3)	
No	2,890 (97.5)	38 (100)	160 (94.1)	2,692 (97.7)	
Anxiety during pregnancy					0.004
Yes	445 (15.5)	10 (27.8)	37 (22.6)	398 (14.9)	
No	2,429 (84.5)	26 (72.2)	127 (77.4)	2,276 (85.1)	
Stress during pregnancy					0.062
Yes	591 (20.1)	12 (33.3)	40 (23.7)	539 (19.7)	
No	2,352 (79.9)	24 (66.7)	129 (76.3)	2,199 (80.3)	

[a] Due to missing data, the sample size across gestational age subgroups is less than n=3,021

[b] Previous psychosocial stress defined as at least one of a history of poor mental health, a history of abuse, or negative feelings about the current pregnancy

[c] Invalid chi-square test due to cells with expected count less than five. Interpret with caution

more likely to be non-Caucasian, have a personal or family history of preterm birth, and report a poor reproductive history such as a previous miscarriage or stillbirth. Women who delivered at less than 34 weeks (early preterm) were more likely to have undergone assisted reproduction technologies, while women who delivered in the late preterm gestational age range were more likely to have pregnancy complications such as preeclampsia or gestational diabetes. Mothers delivering both early and late preterm reported significantly higher rates of cumulative psychosocial stress than mothers delivering at term.

The final multinomial regression model showed that cumulative psychosocial stress was a significant independent risk factor for late preterm birth (OR=1.73; 95 % CI=1.07, 2.81), but not for early preterm birth (OR=2.44; 95 % CI= 0.95, 6.32), controlling for income, a personal or family history of preterm birth, pregnancy complications, reproductive history, and smoking in pregnancy (Table 3). These estimates remained robust to the addition of prenatal perceived stress to the model (results not shown). Given similar cumulative psychosocial stress odds ratio estimates for both early and late preterms and small sample sizes, stratified analyses combined these subgroups and used the standard definition of preterm birth at <37 weeks gestational age. Results showed that among women with medium to high levels of perceived social support or optimism, cumulative psychosocial stress was no longer an independent risk factor for preterm birth, suggestive of a buffering effect of social support and internal coping resources on psychosocial risk (Table 4). Cumulative psychosocial stress was an independent risk factor for preterm birth among women with low levels of social support (OR=2.09; 95 % CI=1.07, 4.07) or optimism (OR=1.87; 95 % CI=1.04, 3.37), but not among women with higher levels of these factors (Table 4).

Discussion

Psychosocial research in pregnant women warrants a multidimensional concept of pregnancy psychosocial stress that involves psychological, social, and physiologic components

Table 3 Adjusted odds ratios for the relation between cumulative psychosocial stress controlling for demographic, obstetrical, medical, and lifestyle risk factors for early or late preterm birth

Risk Factor	Early preterm birth (<34 weeks) versus term birth (≥37 weeks)		Late preterm birth (34–36 weeks) versus term birth (≥37 weeks)	
	aOR	95 % CI	aOR	95 % CI
Low income (<80,000)	*3.72*	*1.68*, *8.23**	*1.67*	*1.16*, *2.41***
History of preterm birth	1.26	0.49, 3.19	1.46	0.98, 2.19
Pregnancy complications	0.36	0.05, 2.66	*2.53*	*1.62*, *3.94**
Reproductive history[a]				
Previously pregnant/not poor hx	*0.35*	*0.13*, *0.92****	0.68	0.44, 1.04
Previously pregnant/poor hx	0.74	0.29, 1.89	1.07	0.69, 1.65
Smoking in pregnancy	0.83	0.24, 2.88	1.26	0.75, 2.09
Cumulative psychosocial stress	2.44	0.95, 6.32	*1.73*	*1.07*, *2.81*****

Abbreviations: *aOR* adjusted odds ratio, *CI* confidence interval

[a] Reference group=not previously pregnant

*p<0.001; **p<0.01; ***p<0.05

(Hogue et al. 2001; Latendresse 2009). A recent meta-analysis on psychosocial stress and perinatal outcomes found consistent but small effects (Littleton et al. 2010), suggesting that further research should include combinations of psychosocial and life course health determinants (Littleton et al. 2010). Similarly, a recent review of population-based studies on stress and obstetric outcomes highlighted a need for future research that adopts a life course approach (Witt et al. 2013). Heeding these calls, the present study sought to examine the combined effect of anxiety symptoms during pregnancy, preconception adversity, and negative feelings toward the current pregnancy. We examined the effect of cumulative psychosocial stress on the risk for early delivery, controlling for established environmental and medical risk factors for preterm birth. Results from the present study showed that cumulative psychosocial stress was a significant independent risk factor for late preterm birth, but not for early preterm birth, controlling for demographic, obstetrical, medical, and lifestyle factors. This is in line with a previous work reporting consistent independent associations between pregnancy anxiety and preterm birth (Kramer et al. 2009) and aligns with the theory of allostatic load, a model deemed appropriate for examining stress-related health outcomes, including perinatal outcomes (Latendresse 2009; Shannon et al. 2007). The lack of evidence for a significant independent effect for early preterm birth could be due to the low number of women giving birth at less than 34 weeks or could suggest a specificity of cumulative psychosocial stress for late preterm birth and overshadowing of medical factors associated with early preterm birth. However, given that the odds ratio estimate for early preterm birth was above 2 and the lower bound of the confidence interval was close to 1, low power is likely an issue for this outcome and the effect of cumulative psychosocial stress appears to be a clinically important risk factor for both early and late preterm births. Although some previous studies have examined associations between psychosocial factors and continuous gestational age, to our knowledge, none have examined gestational subgroups such as early preterm and late preterm births. The rise in late preterm births has been attributed to infertility treatments, increases in maternal age, more multiple gestations, increasing obesity rates, and increases in maternal comorbid conditions (Martin et al. 2010). Quality assurance efforts aimed at decreasing the incidence of elective induction of labor or elective cesarean delivery before 39 weeks have been successful in bringing down the rates of late preterm births (Donovan et al. 2010). Although increasing attention has been paid to psychosocial consequences of a preterm delivery (Davis et al. 2003; Karatzias et al. 2007; Miles et al. 1999; Miles et al. 2007; Zanardo et al. 2003; McDonald et al. 2012), less attention has

Table 4 Association between cumulative psychosocial stress and preterm birth according to levels of perceived social support and dispositional optimism

Stratification variable	Cumulative psychosocial stress aOR (95 % CI)[a]
Social Support	
Low (<25th percentile)	*2.09* (*1.07*,*4.07*)*
Medium (25th to 75th percentile)	1.49 (0.66,3.40)
High (>75th percentile)	1.66 (0.50,5.48)
Optimism	
Low (<25th percentile)	*1.87* (*1.04*,*3.37*)*
Medium to high (>25th percentile)[b]	1.51 (0.70,3.25)

[a] From logistic regression model (preterm vs. term birth) adjusting for income, history of preterm birth, pregnancy complications, reproductive history, and smoking in pregnancy

[b] Given low number in high optimism group, medium and high optimism were collapsed

*p<0.05

been paid to the role of psychosocial factors in the etiology of early preterm and late preterm delivery. In contrast, a large body of research exists on psychosocial factors and *phenotypes* of preterm birth, evidence which suggests distinct biological mechanisms linking perceived emotional and social stress to spontaneous preterm birth through aberrations of maternal endocrine and immune function (Ruiz et al. 2003).

The combined effect of anxiety symptoms with either negative feelings about the current pregnancy or a history of adverse mental health or abuse was associated with increased odds of a late preterm delivery compared to delivering at 37 weeks or more. Perhaps, during pregnancy, a "triggering" effect of previous responses to adversity or intrapsychic processes interacts with anxiety symptoms to increase the risk for delivering in the late preterm gestational age range. We investigated this further by examining the contribution of previous life course stress alone or anxiety symptoms alone on the risk for preterm birth. Indeed, supplementary analyses showed that neither previous psychosocial stress alone nor anxiety symptoms alone conferred risk for early delivery in the multinomial regression analysis (results not shown), while the composite variable that combined previous psychosocial stress and anxiety during pregnancy was indeed a significant risk factor. Alternatively, given that the placenta's ability to protect the fetus from excess concentrations of stress hormones deteriorates with advancing gestational age (Sandman et al. 2011), it may be that cumulative symptoms overwhelm the protective placental function, resulting in high exposure of the fetus to stress hormones. This could also be a plausible mechanism for early preterm delivery given the odds ratio of 2.44, which is deemed clinically significant. The bulk of our early preterms were in the 32–33-week range, suggesting alternate pathways for births less than 32 weeks.

In line with a cumulative risk and life course perspective, previous work reports more consistent and robust associations between preterm birth and chronic stressors that are important to women compared to acute (life events) psychosocial stressors (Hoffman and Hatch 1996), likely mediated though stress hormones such as corticotrophin-releasing hormone (Sandman et al. 1997). Our cumulative psychosocial stress construct could reflect such accumulation of stress accrued throughout the life course and during pregnancy. Furthermore, cumulative psychosocial stress was a significant risk factor for late preterm delivery even in the presence of perceived stress, which also suggests that earlier experiences have latent effects on gestational length, when combined with anxiety symptoms in pregnancy. These results align with a growing body of research regarding early adversity as a life course social determinant of adult health (Greenfield 2010; Shonkoff et al. 2009; Shonkoff and Garner 2012) including pregnancy and childbirth outcomes (Lukasse et al. 2009; Lukasse et al. 2010; Leeners et al. 2006).

The evidence remains equivocal as to the buffering effect of social support on the association between maternal psychosocial factors during pregnancy and poor pregnancy outcomes. Although this interaction was reported as early as 1972, subsequent investigations have produced mixed findings (Hogue et al. 2001). Our findings suggest that at least medium levels of perceived social support buffer the effect of cumulative psychosocial stress on the risk of a preterm birth. Some studies that have examined a buffering effect of social support on preterm birth have examined it as a main effect in observational research or in the context of a randomized trial (Hoffman and Hatch 1996; Ruiz et al. 2003). Discrepant findings across studies could be due to methodological issues including study design and analysis as well as different social support measures and cutoffs, timing of assessments, and sample composition. We categorized social support into low, medium, and high to examine whether the buffering effect included only extreme levels of social support or extended to adequate levels as well. To this end, we found that the risk associated with cumulative psychosocial stress was mitigated among women reporting at least medium levels of social support. Although not explicitly tested, our results suggest that the combined effect of cumulative psychosocial stress and low social support conveyed risk for preterm birth. Further analyses examining the extent to whether this combined effect is additive or multiplicative will help inform strategies for intervention. For example, the presence of an additive interaction is congruent with biological interaction and causal interpretations, important for assessing the public health impact of interactions (Ruiz et al. 2003). Furthermore, some previous studies have found that that social support, in particular tangible or instrumental support, buffered women against the risk of antenatal depression, which in turn improved pregnancy outcomes, especially birth weight. This is consistent with the lack of a direct relationship that some have found between social support and poor pregnancy outcomes (Heaman et al. 2013) and implies that social support may play more of an indirect role with respect to birth outcomes. Other studies examining a group prenatal care approach that endorses a social support framework during prenatal care have noted enhanced physician experiences, decreased maternal psychosocial risk, and improved birth outcomes (McNeil et al. 2012, 2013; Benediktsson et al. 2013; Ickovics et al. 2007; Ickovics et al. 2011). It could be that the interactive effect depends on both the type of social support (instrumental vs. emotional) and type of negative affect (depression vs. anxiety). Animal models show that social support and sense of control can ameliorate the physiological stress response of the HPA axis (Levine 1993); less is known about the maternal physiological stress response to these buffering factors in human studies.

Dispositional optimism, a marker of resiliency and internal coping resources, could reflect an individual's projected sense of control. Consistent with previous studies, we conceptualized a woman's level of optimism as an invariant quality, more reflective of a "trait" rather than a "state," capturing a woman's general sense of personal control or mastery over life (Major

et al. 1998; Lobel et al. 2000). We found that among women with medium to high levels of dispositional optimism, cumulative psychosocial stress was not significantly associated with preterm birth. This suggests that a woman's projected sense of control may alter the physiological response of cumulative psychosocial stress in pregnancy, akin to observations seen in animal studies, which in turn improves pregnancy outcomes. Further investigation regarding mechanisms that underlie the buffering effects of social relationships and resiliency is clearly warranted, especially given that our social support variable measured a woman's perceived social support in contrast to a more objective measure and we used a proxy of sense of control with our optimism variable compared to a direct measure of mastery. Only a few studies have examined maternal optimism in relation to birth outcomes. One small study of high-risk pregnant women reported a positive association between optimism and birth weight and an indirect association with gestational length, likely mediated through reduced anxiety (Rini et al. 1999). In contrast to our study, the authors did not report a buffering effect of personal coping resources on the negative association between stress and gestational length (Rini et al. 1999). Discrepancies could be due to different sample compositions and different psychosocial factors under investigation. In line with our findings regarding perceived social support, for women with medium to high optimism, cumulative psychosocial stress was not an independent risk factor for preterm birth. Taken together, this suggests that coping resources, defined here as perceived social support and optimism, may mitigate psychosocial risk on birth outcomes.

This study is not without limitations. Our operationalization of cumulative psychosocial stress requires further validation in future studies that not only include the same constructs that comprise our cumulative variable but also a pregnancy-specific anxiety measure. In addition, we did not include a measure of stressful life events in our cumulative psychosocial stress variable as this was not administered in the study. The inclusion of pregnancy complications in our model limited the sample size for multinomial regression analysis as successful linkage to electronic health record data occurred for only 85 % of the sample (McDonald et al. 2013), suggesting a potential for selection bias in this study. However, similar proportions of preterm birth and associated risk factors were seen in the group of women with missing electronic health record data (n=356) and in the full sample (Table 2). Importantly, similar magnitudes of effects were observed between those risk factors for preterm birth not extracted from the medical chart (e.g., history of preterm birth) in both samples, suggesting low risk for selection bias. Finally, although we utilized different data sources to account for key preterm birth risk factors, we cannot rule out residual confounding due to either unmeasured or poorly measured confounding variables.

Strengths of the current study include its prospective design and assessment of a number of factors allowing for developing a cumulative psychosocial stress variable as well as adjustment for key preterm birth risk factors. Lines of investigation that adopt life course, bio-behavioral, or allostatic load approaches contribute valuable information for increasing the understanding of explanatory pathways underlying associations between psychosocial stress and birth outcomes, including preterm birth (Hobel 2004; Latendresse 2009). This study is no exception as its life course approach allowed for identifying a broader group of women who may be at risk of early delivery, results which can inform prevention and intervention efforts, especially for deliveries between 34 and 36 weeks gestational age.

Conclusion

Our analyses suggest that early vulnerability combined with current anxiety symptoms in pregnancy confers risk for preterm birth. From a public health perspective, given that late preterm births constitute the largest and fastest growing subgroup of preterm births, attending to modifiable risk factors specific to late preterm deliveries could have a large population impact. Coping resources may mitigate the effect of cumulative psychosocial stress on the risk for early delivery.

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Ethical standards This study was approved by the appropriate ethics committee and therefore was performed in accordance with the ethical stands laid down in the 1964 Declaration of Helsinki and its later amendments.

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

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