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ORIGINAL ARTICLE

Infant birthweight in the US: the role of preconception stressful life events and substance use

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Abstract The purpose of this study was to determine the relationships among preconception stressful life events (PSLEs), women's alcohol and tobacco use before and during pregnancy, and infant birthweight. Data were from the *Early Childhood Longitudinal Study-Birth Cohort* (n=9,350). Data were collected in 2001. Exposure to PSLEs was defined by indications of death of a parent, spouse, or previous live born child; divorce or marital separation; or fertility problems prior to conception. Survey data determined alcohol and tobacco usage during the 3 months prior to and in the final 3 months of pregnancy. We used staged multivariable logistic regression to estimate the effects of women's substance use and PSLEs on the risk of having a very low (<1,500 g, VLBW) or low (1,500–2,499 g, LBW) birthweight infant, adjusting for confounders. Women who experienced any PSLE were more likely to give birth to VLBW infants (adjusted odds ratio [AOR]= 1.35; 95 % confidence interval [CI]=1.10–1.66) than women who did not experience any PSLE. Compared to women who never smoked, women who smoked prior to conception (AOR=1.31; 95 % CI=1.04–1.66) or during their last trimester (AOR=1.98; 95 % CI=1.56–2.52) were more likely to give birth to LBW infants. PSLEs and women's tobacco use before and during pregnancy are independent risk factors for having a lower birthweight baby. Interventions to improve birth outcomes may need to address women's health and health behaviors in the preconception period.

Keywords Alcohol and tobacco use prior to and during pregnancy · Preconception stressful life events · Substance use · Infant birth weight · Lifecourse

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Introduction

In the past decade, research has highlighted the link between preconception stressful life events (PSLEs) and poor obstetric outcomes, including low birthweight (LBW) and preterm birth (Class et al. 2011; Khashan et al. 2008; Witt et al. 2014a, b, c, 2015b). However, the exact mechanisms by which maternal stress across the lifecourse influences obstetric outcomes have not been definitively identified. Though researchers have proposed various mechanisms, one potential pathway by which stress may negatively affect intergenerational morbidity and mortality is through a resulting increase in poor maternal health behaviors (McCormick et al. 1990; Weaver et al. 2008; Witt et al. 2015a), including alcohol and tobacco use.

Findings from the extant research that has examined the relationships among prenatal stress, substance use (including alcohol and tobacco use), and obstetric outcomes are equivocal. For example, several studies using convenience samples report that while stress or stressors are predictive of substance use during pregnancy, there is no direct relationship between prenatal stress and obstetric outcomes (Lobel et al. 2008; McCormick et al. 1990). In contrast, other studies have shown that prenatal stress and substance abuse are *independent* risk factors for LBW (Brooke et al. 1989; Grjibovski et al. 2004), preterm birth (Lobel et al. 2008; Nordentoft et al. 1996), and reduced head circumference at birth (Singer et al. 2002). A state-level population-based study found that women who reported low pregnancy-related mood levels were twice as likely to have LBW infants, regardless of their smoking status. This study also found that cigarette use increased the risk for LBW among women who had high pregnancy-related mood levels, but added no additional risk among women with low pregnancy-related mood (Gyllstrom et al. 2011). These differences across previous studies are likely due to differences in the study population, conceptualization and measurement of prenatal stress, and analytic approach. Therefore, further research is warranted to better clarify the relationships among women's stress and stressors, substance use, and obstetric outcomes.

To date, there has been no nationally representative examination of whether the use of alcohol and tobacco before and during pregnancy may be an important mediator in the relationship between women's exposure to stressors and negative obstetric outcomes. In addition, to our knowledge, no study has examined PSLEs and women's health behaviors simultaneously to investigate this potential pathway leading to infant LBW. Notably, recent studies have shown that PSLEs may be a better predictor of obstetric outcomes than prenatal stressful life events (Witt et al. 2014a, b, c); however, the role of substance use in this context is not fully understood. This study therefore adopted a lifecourse approach to determine if and to what extent stressful life events and alcohol and tobacco use before and during pregnancy increase the risk for giving birth to a very low birthweight (VLBW) or LBW baby.

Materials and methods

We drew data from the first wave of the *Early Childhood Longitudinal Study-Birth Cohort* (ECLS-B), a nationally representative cohort of children born in 2001 and their parents. The ECLS-B used a clustered, list-frame design to select a probability sample of the approximately 4 million children born in 2001, with oversampling of children from minority groups, twins, and children born VLBW and LBW (National Center for Education Statistics 2001). Children born to mothers younger than 15 years of age, those who were adopted after the birth certificate was issued, and those who did not survive until 9 months of age were excluded from the sampling frame (Snow et al. 2009). Registered births were sampled within primary sampling units (counties or groups of contiguous counties) from the National Center for Health Statistics vital statistics system. Over 14,000 births were sampled and contacted; from these sampled births, the final study cohort (consisting of completed 9-month interviews) of 10,700 was formed when the children were approximately 9 months old. The first wave of the study occurred when the child was approximately 9 months old. Data were collected from the infant's birth certificate, computer-assisted personal interviews, and parental self-administered questionnaires.

We obtained restricted data from the Institute for Education Sciences (IES) Data Security Office of the US Department of Education, National Center for Education Statistics (NCES). In accordance with NCES guidelines, we rounded all reported unweighted sample sizes to the nearest 50 (National Center for Education Statistics 2001). This research was considered exempt from review by the University of Wisconsin–Madison Health Sciences institutional review board.

Participants were eligible for this study if the main survey respondent was the infant's biological mother (n=10,550); we excluded 450 additional records missing birth certificate data. ECLS-B included individual records for each child within twin pairs identified through oversampling; for this analysis, we randomly selected one twin from each pair to retain in the sample. For other multiples in the sample (i.e., not explicitly recruited as part of the oversampling), only one infant from in the household was surveyed. Our final sample contained 9,350 mother–child dyads.

Measures

Birthweight The child's birthweight was derived from the birth certificate and categorized as very low (VLBW; less than 1,500 g), low (LBW; between 1,500 and 2,499 g), normal (NBW; between 2,500 and 3,999 g), or high (HBW; 4,000 g or more).

Alcohol and tobacco use Women were asked about their alcohol and tobacco usage during the 3 months prior to their pregnancies and in the final 3 months of their pregnancies; self-reported responses were categorized into three mutually exclusive categories: (1) use in the 3 months prior to conception *only*, (2) *any* use in the final 3 months of pregnancy or (3) no use before or during pregnancy (i.e., never).

Stressful life events prior to conception The date of conception was derived using birth certificate data on the length of gestation and the infant's date of birth. Following previous work (Witt et al. 2014a, b, c, 2015a, b), women were coded as having experienced a PSLE if they indicated that one or more of the

following events occurred prior to conception: (1) death of the respondent's mother, (2) death of the respondent's father, (3) death of a previous live born child, (4) divorce, (5) separation from partner, (6) death of a spouse, or (7) fertility problems. All of these experiences were considered or operationalized as stressful life events in previous research (Holmes and Rahe 1967; Witt et al. 2014a, b, c, 2015a, b). Data on death of a previous live born child were collected from the birth certificate and were assumed to have occurred prior to conception.

Prenatal health and stress Birth certificate data determined if women had experienced any of the following pregnancy complications: anemia, diabetes, (oligo) hydramnios, hypertension during pregnancy, eclampsia, incompetent cervix, Rh sensitization, uterine bleeding, premature rupture of membranes, placental abruption, or placenta previa. Birth certificate data also identified women who had previously delivered a preterm or small for gestational age (SGA) infant and women with chronic conditions (including cardiac disease, lung disease, genital herpes, hemoglobinopathy, chronic hypertension, renal disease, or other medical risk factors). Prepregnancy body mass index (BMI [kilograms divided by meters squared]) was calculated from the respondent's measured height and self-reported weight prior to pregnancy (less than 18.5 kg/m^2 [underweight], between 18.5 and 24.9 kg/m^2 [normal], between 25 and 29.9 kg/m^2 [overweight], 30 kg/m^2 or more [obese], and unknown) (National Heart, Lung, and Blood Institute 2000). We also evaluated the timing of prenatal care initiation (first trimester, second or third trimester, or did not receive prenatal care) and whether women had a previous live birth (yes or no). Women were coded as having experienced a stressful life event *during* pregnancy if they indicated that any of the following events occurred during their pregnancy: (1) death of the respondent's mother, (2) death of the respondent's father, (3) divorce, (4) separation from partner, or (5) death of a spouse.

Maternal sociodemographic factors Maternal sociodemographic factors included race/ethnicity (White [non-Hispanic], Black [non-Hispanic], Asian/Pacific Islander [non-Hispanic], Hispanic, or other race [non-Hispanic]), age (15–19, 20–24, 25–29, 30–34, or 35 years or older), marital status at the infant's birth (married or living with partner, separated, divorced, widowed, or never married), health insurance coverage during pregnancy (no health insurance, any publicly funded insurance, or private health insurance coverage only), US region of residence (Northeast, Midwest, South, or West), and socioeconomic status (SES). SES was defined using a five-category composite index (quintiles) generated by the NCES that incorporated (1) father's or male guardian's education, (2) mother's or female guardian's education, (3) father's or male guardian's occupation, (4) mother's or female guardian's occupation, and (5) household income (National Center for Education Statistics 2001).

Statistical analyses

Analyses were conducted with SAS 9.2 (SAS Institute, Cary, North Carolina). The standard errors were corrected for clustering within strata and the primary sampling unit, and survey weights were applied to produce estimates accounting for the complex survey design, unequal probabilities of selection, and survey non-response. We generated summary statistics to describe sample characteristics and used chi square and *t* tests to determine significant differences in maternal sociodemographic characteristics by infant birthweight status.

We then used staged multivariable multinomial regression models to examine the impact of (1) maternal exposure to PSLEs on the infant's birthweight status and (2) whether alcohol and cigarette use prior to conception and during pregnancy attenuated that effect. Model 1 examined the unadjusted effect of PSLEs on the odds of VLBW and LBW. Model 2 examined whether this effect was attenuated by the inclusion of alcohol and cigarette use prior to and during pregnancy without including other covariates. Model 3 additionally adjusted for exposure to any stressful life event during pregnancy, pregnancy complications, having a previous preterm or SGA baby, maternal chronic conditions, prepregnancy BMI, initiation of prenatal care, plurality, parity, maternal race/ethnicity, maternal age, marital status at birth, health insurance coverage, region of residence, and SES.

Results

PSLEs were experienced by 19.7 % of mothers (Table 1). Mean birthweight of the cohort was 3,333 g (SD=583 g); 1.2 % of women delivered a VLBW baby, and 5.6 % of women delivered a LBW baby.

Over one third (34.8 %) of women reported alcohol use during the 3 months prior to pregnancy only, while 3.3 % reported using any alcohol in the final 3 months of their pregnancies. There were no significant differences in alcohol use by infant birthweight. Overall, 12.3 % of women reported tobacco use during the 3 months *prior* to pregnancy only and 11.0 % of women reported any tobacco use in the final 3 months of pregnancy. There were significant differences in preconception and prenatal tobacco use by infant birthweight, with lower rates of tobacco use *prior* to pregnancy among women who delivered NBW (12.0 %) infants compared to VLBW (13.6 %), LBW (13.4 %), and HBW (14.1 %) infants and significantly higher rates of *prenatal* tobacco use among mothers who delivered VLBW (13.8 %) and LBW (18.4 %) infants, compared to NBW (11.1 %) and HBW (4.7 %) infants.

In unadjusted analyses, women who experienced any PSLE were more likely to deliver a VLBW infant (OR= 1.73; 95 % CI=1.48–2.01, Table 2, Model 1). Controlling for alcohol and tobacco use prior to and during pregnancy did not attenuate this effect in Model 2, suggesting that

Table 1 Maternal alcohol and tobacco use and descriptive characteristics by infant birthweight status, *Early Childhood Longitudinal Study-Birth Cohort* (ECLS-B), 2001

	Total	Birthweight (categorical)				
		VLBW	LBW	NBW	HBW	*P* value
Total (weighted)	3,774,441	44,755	208,987	3,160,613	360,086	
%		1.2 %	5.6 %	84.3 %	9.6 %	
Total (unweighted)	9,350	1,000	1,200	6,500	650	
Birthweight (g), mean [SD]	3,333 [583]	1,044 [828]	2,190 [398]	3,334 [332]	4,270 [204]	<0.001
Birthweight (g), median	3,373	1,036	2,266	3,344	4,196	
Alcohol and tobacco use						
Alcohol use						0.272
None	61.8 %	63.5 %	62.9 %	62.0 %	59.6 %	
In 3 months prior to conception only	34.8 %	33.8 %	33.4 %	34.5 %	38.6 %	
In final 3 months of pregnancy	3.3 %	2.7 %	3.7 %	3.5 %	1.9 %	
Cigarette use						<0.001
None	76.8 %	72.6 %	68.2 %	76.9 %	81.2 %	***
In 3 months prior to conception only	12.3 %	13.6 %	13.4 %	12.0 %	14.1 %	***
In final 3 months of pregnancy	11.0 %	13.8 %	18.4 %	11.1 %	4.7 %	***
Stress and obstetric factors						
Stressful life events prior to conception						<0.001
None	80.3 %	71.3 %	76.1 %	81.1 %	76.9 %	
Any	19.7 %	28.7 %	23.9 %	18.9 %	23.1 %	
Number of stressful life events prior to conception, mean [SD]	0.2 [0.5]	0.4 [1.9]	0.3 [0.9]	0.2 [0.4]	0.3 [0.5]	<0.001
Stressful life events during pregnancy						<0.001
None	94.2 %	93.5 %	91.8 %	94.2 %	96.2 %	
Any	5.8 %	6.5 %	8.2 %	5.8 %	3.8 %	
Pregnancy complications						<0.001
None	86.4 %	57.5 %	70.1 %	87.9 %	86.4 %	
Any	13.6 %	42.5 %	29.9 %	12.1 %	13.6 %	
Maternal chronic conditions						<0.001
None	79.4 %	60.0 %	69.5 %	80.5 %	78.5 %	
Any	20.6 %	40.0 %	30.5 %	19.5 %	21.5 %	
Prior child born preterm or SGA						<0.001
No	99.0 %	95.9 %	96.7 %	99.1 %	99.4 %	
Yes	1.0 %	4.1 %	3.3 %	0.9 %	0.6 %	
Prepregnancy body mass index						<0.001
BMI<18.5	3.3 %	6.1 %	5.1 %	3.4 %	1.3 %	***
18.5≤BMI<25	49.5 %	42.6 %	53.0 %	50.6 %	38.5 %	***
25≤BMI<30	26.8 %	25.1 %	21.8 %	26.8 %	30.1 %	*
BMI≥30	17.9 %	23.5 %	16.9 %	16.9 %	26.4 %	***
Unknown	2.5 %	2.8 %	3.2 %	2.3 %	3.8 %	
Initiation of prenatal care						<0.001
In the first trimester	95.5 %	94.0 %	93.0 %	95.6 %	96.3 %	*
In the second or third trimester	4.2 %	4.2 %	6.2 %	4.1 %	3.7 %	
Did not receive prenatal care	0.3 %	1.8 %	0.9 %	0.3 %	0.0 %	**
Number of children born						<0.001
Singleton	98.3 %	81.3 %	86.2 %	99.1 %	100.0 %	
Multiple	1.7 %	18.7 %	13.8 %	0.9 %	0.0 %	
Parity[a]						<0.001
Nulliparous	40.7 %	46.0 %	46.0 %	41.1 %	33.5 %	***

Table 1 (continued)

	Total	Birthweight (categorical)				
		VLBW	LBW	NBW	HBW	*P* value
Primiparous	32.8 %	25.7 %	27.2 %	32.9 %	36.2 %	***
Multiparous	26.5 %	28.3 %	26.7 %	26.0 %	30.3 %	**
Maternal sociodemographic factors						
Age (years)						<0.001
15–19	7.5 %	8.9 %	10.7 %	7.3 %	6.7 %	*
20–24	24.2 %	25.0 %	27.6 %	24.9 %	16.1 %	***
25–29	26.2 %	22.0 %	20.9 %	26.5 %	27.1 %	*
30–34	25.0 %	26.8 %	20.6 %	24.8 %	28.8 %	**
35+	17.1 %	17.3 %	20.2 %	16.4 %	21.3 %	**
Race/ethnicity						<0.001
White (non-Hispanic)	57.4 %	45.9 %	49.8 %	56.9 %	67.4 %	***
Black (non-Hispanic)	14.1 %	27.5 %	23.5 %	14.0 %	7.5 %	***
Asian/Pacific Islander (non-Hispanic)	3.5 %	2.5 %	3.6 %	3.7 %	1.7 %	***
Other (non-Hispanic)	2.5 %	1.9 %	2.3 %	2.6 %	1.6 %	
Hispanic	22.6 %	22.2 %	20.8 %	22.8 %	21.7 %	
Marital status (at birth)						<.001
Married or living with partner	83.4 %	77.1 %	75.9 %	83.4 %	88.9 %	***
Separated/divorced/widowed	3.1 %	3.0 %	3.2 %	3.1 %	2.3 %	
Never married	13.5 %	19.9 %	20.9 %	13.5 %	8.8 %	***
Health insurance status						<0.001
Private only	59.1 %	52.0 %	50.4 %	58.8 %	68.0 %	***
Any public	37.4 %	43.6 %	45.9 %	37.8 %	29.0 %	***
None	3.4 %	4.3 %	3.8 %	3.4 %	3.0 %	
Socioeconomic status						<0.001
First quintile (lowest)	19.7 %	23.9 %	24.8 %	19.7 %	16.2 %	***
Second quintile	20.0 %	24.0 %	24.1 %	20.2 %	15.6 %	**
Third quintile	20.1 %	20.9 %	20.2 %	19.9 %	21.1 %	
Fourth quintile	20.2 %	16.8 %	16.1 %	20.2 %	22.2 %	*
Fifth quintile (highest)	20.1 %	14.3 %	14.7 %	20.0 %	24.8 %	***
Region of residence						0.124
Northeast	17.1 %	17.7 %	15.3 %	16.8 %	20.1 %	
Midwest	22.3 %	21.5 %	22.0 %	22.2 %	23.4 %	
South	36.9 %	41.4 %	40.0 %	36.9 %	34.8 %	
West	23.8 %	19.4 %	22.7 %	24.1 %	21.7 %	

Source: 2001 ECLS-B. Data are weighted percentages or means [SDs]. National Center for Education Statistics (NCES) rounding rules applied to unweighted *N*s; unweighted subgroup *N*s may not add to the total due to rounding error

VLBW very low birthweight (<1500 g), *LBW* low birthweight (1500 to 2499 g), *NBW* normal birthweight (2500 to 3999 g), *HBW* high birthweight (≥4000 g), *SD* standard deviation, *SGA* small for gestational age, *BMI* body mass index

Subgroup post hoc *P* values: **P*<0.05; ***P*<0.01; ****P*<0.001

[a] Parity of the mother not including her most recent live birth

PSLEs and alcohol and tobacco use exert independent effects on infant birthweight (Table 2, Model 2). However, tobacco use prior to (adjusted OR [AOR]=1.22; 95 % CI=1.00–1.47) and during pregnancy (AOR=1.27; 95 % CI=1.02–1.58) were independently associated with an increase in the odds of having a VLBW baby. Alcohol use at either time point was not associated with the odds of having a VLBW baby in the adjusted models.

After additionally adjusting for obstetric and sociodemographic factors, the effect of PSLEs was attenuated

Table 2 Multinomial logistic regression modeling very low birthweight[a] predicted by stressful life events prior to conception, alcohol and tobacco use, maternal health, and sociodemographic factors, *Early Childhood Longitudinal Study-Birth Cohort* (ECLS-B), 2001

	Model 1			Model 2			Model 3		
	AOR	95 % CI	*P* value	AOR	95 % CI	*P* value	AOR	95 % CI	*P* value
Stressful life events									
Stressful life events prior to conception									
None	1.00	Reference		1.00	Reference		1.00	Reference	
Any	**1.73**	**1.48 2.01**	***	**1.72**	**1.47 2.00**	***	**1.35**	**1.10 1.66**	**
Stressful life events during pregnancy									
None	1.00	Reference		1.00	Reference		1.00	Reference	
Any	1.17	0.86 1.58		1.13	0.83 1.53		1.01	0.64 1.59	
Alcohol and tobacco use									
Alcohol use									
None				1.00	Reference		1.00	Reference	
In 3 months prior to conception only				0.91	0.79 1.06		1.07	0.88 1.29	
In final 3 months of pregnancy				0.71	0.48 1.04		0.88	0.55 1.44	
Tobacco use									
None				1.00	Reference		1.00	Reference	
In 3 months prior to conception only				**1.22**	**1.00 1.47**	*	1.23	0.99 1.53	
In final 3 months of pregnancy				**1.27**	**1.02 1.58**	*	**1.44**	**1.13 1.83**	**
Obstetric factors									
Pregnancy complications									
None							1.00	Reference	
Any							**4.85**	**4.09 5.75**	***
Maternal chronic conditions									
None							1.00	Reference	
Any							**1.93**	**1.56 2.40**	***
Prior child born preterm or SGA									
No							1.00	Reference	
Yes							**3.74**	**1.90 7.36**	***
Prepregnancy body mass index									
BMI<18.5							**1.89**	**1.31 2.73**	***
18.5≤BMI<25							1.00	Reference	
25≤BMI<30							0.95	0.79 1.14	
BMI≥30							1.14	0.91 1.43	
Unknown							1.06	0.63 1.80	
Initiation of prenatal care									
In the first trimester							1.00	Reference	
In the second or third trimester							0.97	0.71 1.33	
Did not receive prenatal care							3.42	0.99 11.84	
Number of children born									
Singleton							1.00	Reference	
Multiple							**32.69**	**26.47 40.39**	***
Parity[b]									
Nulliparous							1.00	Reference	
Primiparous							**0.58**	**0.48 0.70**	***
Multiparous							**0.58**	**0.46 0.73**	***
Maternal sociodemographic factors									
Age (years)									
15–19							0.93	0.66 1.31	
20–24							0.94	0.75 1.19	

Table 2 (continued)

	Model 1			Model 2			Model 3			
	AOR	95 % CI	*P* value	AOR	95 % CI	*P* value	AOR	95 % CI		*P* value
25–29							1.00	Reference		
30–34							**1.38**	**1.10**	**1.75**	**
35+							1.30	0.94	1.80	
Race/ethnicity										
White (non-Hispanic)							1.00	Reference		
Black (non-Hispanic)							**2.71**	**2.02**	**3.63**	***
Asian/Pacific Islander (non-Hispanic)							1.22	0.78	1.90	
Other (non-Hispanic)							0.61	0.26	1.45	
Hispanic							**1.56**	**1.19**	**2.03**	**
Marital status (at birth)										
Married or living with partner							1.00	Reference		
Separated/divorced/widowed							0.76	0.39	1.49	
Never married							1.05	0.82	1.34	
Health insurance status										
Private only							1.00	Reference		
Any public							0.93	0.73	1.18	
None							1.28	0.77	2.12	
Socioeconomic status										
First quintile (lowest)							**1.78**	**1.19**	**2.65**	**
Second quintile							**1.90**	**1.34**	**2.68**	***
Third quintile							**1.70**	**1.23**	**2.36**	**
Fourth quintile							1.30	0.93	1.82	
Fifth quintile (highest)							1.00	Reference		
Region of residence										
Northeast							0.79	0.58	1.08	
Midwest							1.05	0.86	1.29	
South							1.20	0.98	1.48	
West							1.00	Reference		

Source: 2001 ECLS-B. All models account for complex sampling design of the ECLS-B

AOR adjusted odds ratio, *CI* confidence interval, *SGA* small for gestational age, *BMI* body mass index

[a] Versus normal birthweight

[b] Parity of the mother not including her most recent live birth

*$P<0.05$, ** $P<0.01$, ***$P<0.001$

such that women exposed to any PSLE had 35 % higher odds of having a VLBW baby than women who were not exposed (AOR=1.35; 95 % CI=1.10–1.66; Table 2, Model 3). Women's alcohol use was not associated with VLBW; however, tobacco use in the 3 months *prior* to pregnancy (AOR=1.23, 95 % CI=0.99–1.53)[1] and *during* the final 3 months of pregnancy (AOR=1.44, 95 % CI=1.13–1.83) remained independent predictors of VLBW. These relationship did not change from those observed in Model 2 (Table 2), which controlled only for PSLEs.

While exposure to PSLEs was associated with increased odds of delivering a LBW baby (unadjusted OR=1.36; 95 % CI=1.11–1.66, Table 3, Model 1), this effect was not attenuated by substance use prior to and during pregnancy (Table 3, Model 2), but by obstetric and sociodemographic factors (Table 3, Model 3). Similar to the results for VLBW, tobacco use prior to (AOR=1.28; 95 % CI=1.05–1.55) and during (AOR=1.80; 95 % CI=1.48–2.18) pregnancy was independently associated with an increase in the odds of having a LBW baby. No relationship was observed between alcohol

[1] While this relationship did not achieve statistical significance, it is suggestive of an association.

Table 3 Multinomial logistic regression modeling low birthweight[a] predicted by stressful life events prior to conception, alcohol and tobacco use, maternal health, and sociodemographic factors, *Early Childhood Longitudinal Survey-Birth Cohort* (ECLS-B), 2001

	Model 1			Model 2			Model 3		
	AOR	95 % CI	*P* value	AOR	95 % CI	*P* value	AOR	95 % CI	*P* value
Stressful life events									
Stressful life events prior to conception									
None	1.00	Reference		1.00	Reference		1.00	Reference	
Any	**1.36**	**1.11 1.66**	**	**1.32**	**1.08 1.61**	**	1.11	0.88 1.39	
Stressful life events during pregnancy									
None	1.00	Reference		1.00	Reference		1.00	Reference	
Any	**1.48**	**1.09 2.00**	*	1.36	0.99 1.86		1.29	0.86 1.94	
Alcohol and tobacco use									
Alcohol use									
None				1.00	Reference		1.00	Reference	
In 3 months prior to conception only				0.90	0.78 1.04		1.01	0.86 1.19	
In final 3 months of pregnancy				0.95	0.63 1.42		1.13	0.73 1.73	
Tobacco use									
None				1.00	Reference		1.00	Reference	
In 3 months prior to conception only				**1.28**	**1.05 1.55**	*	**1.31**	**1.04 1.66**	*
In final 3 months of pregnancy				**1.80**	**1.48 2.18**	***	**1.98**	**1.56 2.52**	***
Obstetric factors									
Pregnancy complications									
None							1.00	Reference	
Any							**3.02**	**2.45 3.73**	***
Maternal chronic conditions									
None							1.00	Reference	
Any							**1.39**	**1.14 1.71**	**
Prior child born preterm or SGA									
No							1.00	Reference	
Yes							**3.32**	**1.90 5.81**	***
Prepregnancy body mass index									
BMI<18.5							1.25	0.88 1.78	
18.5≤BMI<25							1.00	Reference	
25≤BMI<30							**0.72**	**0.58 0.89**	**
BMI≥30							**0.74**	**0.61 0.91**	**
Unknown							1.09	0.66 1.80	
Initiation of prenatal care									
In the first trimester							1.00	Reference	
In the second or third trimester							1.34	0.97 1.85	
Did not receive prenatal care							1.61	0.44 5.84	
Number of children born									
Singleton							1.00	Reference	
Multiple							**23.73**	**19.35 29.09**	***
Parity[b]									
Nulliparous							1.00	Reference	
Primiparous							**0.66**	**0.56 0.79**	***
Multiparous							**0.64**	**0.50 0.80**	***
Maternal sociodemographic factors									
Age (years)									
15–19							1.12	0.75 1.67	
20–24							1.05	0.83 1.33	
25–29							1.00	Reference	

Table 3 (continued)

	Model 1			Model 2			Model 3			
	AOR	95 % CI	*P* value	AOR	95 % CI	*P* value	AOR	95 % CI		*P* value
30–34							1.16	0.91	1.46	
35+							**1.74**	**1.32**	**2.30**	***
Race/ethnicity										
White (non-Hispanic)							1.00	Reference		
Black (non-Hispanic)							**2.10**	**1.72**	**2.56**	***
Asian/Pacific Islander (non-Hispanic)							**1.44**	**1.13**	**1.83**	**
Other (non-Hispanic)							0.80	0.46	1.41	
Hispanic							**1.26**	**1.02**	**1.55**	*
Marital status (at birth)										
Married or living with partner							1.00	Reference		
Separated/divorced/widowed							0.79	0.46	1.36	
Never married							1.11	0.87	1.42	
Health insurance status										
Private only							1.00	Reference		
Any public							1.00	0.81	1.24	
None							1.13	0.71	1.80	
Socioeconomic status										
First quintile (lowest)							**1.54**	**1.09**	**2.17**	*
Second quintile							**1.65**	**1.23**	**2.20**	***
Third quintile							**1.50**	**1.13**	**1.98**	**
Fourth quintile							1.19	0.89	1.59	
Fifth quintile (highest)							1.00	Reference		
Region of residence										
Northeast							**0.67**	**0.55**	**0.83**	***
Midwest							0.92	0.77	1.10	
South							1.00	0.84	1.18	
West							1.00	Reference		

Source: 2001 ECLS-B. All models account for complex sampling design of the ECLS-B

AOR adjusted odds ratio, *CI* confidence interval, *SGA* small for gestational age, *BMI* body mass index

[a] Versus normal birthweight

[b] Parity of the mother not including her most recent live birth

*$P<0.05$, ** $P<0.01$, ***$P<0.001$

use at either time point and the likelihood of having a LBW baby in the adjusted models.

Discussion

To our knowledge, this is the first study to examine the relationships among PSLEs, women's alcohol and tobacco use, and infant birthweight using a nationally representative US sample. Previous work has shown that women's exposure to PSLEs was associated with poor obstetric outcomes (Khashan et al. 2008; Witt et al. 2014a, b, c, 2015a, b). In this study, we hypothesized that poor health behaviors before and during pregnancy may be a pathway by which this occurs. However, we found no evidence for alcohol or tobacco use attenuating the impact of PSLEs on birthweight. Rather, PSLEs and tobacco use before and during pregnancy were independent risk factors for lower birthweight. This finding extends previous research which has shown that stress and substance use *during* pregnancy may both be risk factors for poor obstetric outcomes (Grjibovski et al. 2004; Lobel et al. 2008; Nordentoft et al. 1996; Schneider et al. 2002; Singer et al. 2002). Our research suggests that women's tobacco use and exposure to PSLEs are associated with lower infant birthweight, indicating that the critical period for infant health may extend earlier to the preconception period.

These findings have important implications for clinical practice. First, our findings support the established paradigm around maternal substance use during pregnancy and further suggest that reducing smoking *both before and during*

pregnancy stand to improve infant birthweight. Women who smoke before pregnancy are more likely to continue smoking during pregnancy (Witt et al. 2015a), and this study identified that smoking at both time points increased the risk of delivering a LBW infant. Cessation efforts should therefore occur before pregnancy and continue to be offered to women throughout pregnancy in order to mitigate these harmful effects. Smoking cessation interventions are effective during pregnancy (Dolan-Mullen et al. 1994; Chamberlain et al. 2013; Tong et al. 2009; Windsor et al. 1985), and such interventions could be offered in the preconception period as well. Preconception interventions may be critical for identifying high-risk women, namely heavy smokers who may be less likely to quit during pregnancy (Cnattingius et al. 1992; Tong et al. 2009).

Second, clinicians may want to increase awareness of and screening for PSLEs among their patients, as women exposed to PSLEs are more likely to have poor obstetric outcomes. Although we did not find evidence to suggest that the effect of PSLEs is attenuated by substance use, previous work has demonstrated that exposure to PSLEs is associated with increased tobacco use prior to and during pregnancy, as well as an increased amount of alcohol use during pregnancy (Witt et al. 2015a). As such, screening for and intervening on stressors in the preconception period may be doubly effective for improving obstetric outcomes.

Overall, interventions to improve infant birthweight may need to shift the clinical paradigm upstream to the preconception period, and efforts should be made to prevent smoking both before and during pregnancy and to reduce women's exposure to stress over the lifecourse. In fact, several substance use screening instruments and guidelines have been shown to be effective in promoting cessation among women of childbearing age (Floyd et al. 2008; US Surgeon General 2001). However, women who simultaneously use tobacco and other substances may be the least likely to achieve cessation through traditional avenues (Harrison and Sidebottom 2009; Pirie et al. 2000; Zimmerman et al. 1990); therefore, multimodal interventions that address these interrelated behaviors may be warranted (Harrison and Sidebottom 2009; Pirie et al. 2000). Moreover, since preconception care stands to prevent or reduce women's unhealthy behaviors (Xaverius and Salas 2013), it may be critical to include PSLEs in existing preconception screening tools. In contrast, little existing research has identified effective, evidence-based strategies to reduce the biological effects of stressful life events. Such interventions might include incorporation of coping strategies and support interventions into clinical practice or creating modules which educate women on self-efficacy, self-esteem, and the importance of social support (Wakeel et al. 2013). Future research should identify effective programs of intervention at the individual and population levels.

This research may also have implications for health policy. Namely, Healthy People 2020 includes several objectives to reduce alcohol and tobacco use, particularly among reproductive-aged and pregnant women (US Department of Health and Human Services, Office of Disease Prevention and Health Promotion 2013). In addition, health plans are required to provide universal alcohol and tobacco screening and cessation services for all adults, with expanded services for pregnant women, as part of the Affordable Care Act (Johnson 2010). Despite these health policy goals, fewer than half of providers screen pregnant women for alcohol and tobacco use using evidence-based screening tools (Anderson et al. 2010; Okoli et al. 2010). Consequently, additional incentives to providers may help to ensure that women receive appropriate screening and cessation services (US Department of Health and Human Services 2008). The findings from this study suggest that there is a need for expanded policy to encourage providers to screen for and address PSLEs and alcohol and tobacco use in the preconception period.

Although this study found no evidence of a relationship between alcohol use (either before or during pregnancy) and birthweight, it is recognized that even relatively small amounts of alcohol consumption during pregnancy can increase the risk of LBW (Kramer 1987; Mills et al. 1984; Patra et al. 2011). Our null findings may be due to two factors. First, relatively few women (3.3 %) reported any alcohol use during pregnancy, possibly due to the stigma surrounding this behavior during pregnancy; thus, this small sample size may have prohibited meaningful analyses of alcohol use during pregnancy. Second, the ECLS-B queried women about alcohol use during the final 3 months of pregnancy only. Thus, it is possible that women who consumed alcohol during early pregnancy may have stopped drinking prior to their final 3 months of pregnancy and may have been misclassified as unexposed. Such misclassification could have led to an underestimation of fetal exposure to alcohol and biased the results to the null.

Several potential limitations should be considered when interpreting the results of this study. First, children who died before 9 months of age were not eligible to participate in the ECLS-B. Our study therefore likely excluded the children with the worst birth outcomes, a potential survival bias leading to conservative estimates of the effect of PSLEs, alcohol, and tobacco on infant birthweight (Class et al. 2013). In addition, relying on self-reported data may bias our findings in an unknown direction. Women may have underreported their alcohol and tobacco use prior to conception and during pregnancy (Ernhart et al. 1988; Jacobson et al. 2002; Morrow-Tlucak et al. 1989) or may have used alcohol or tobacco outside of the windows that were assessed in the survey (i.e., 3 months prior to pregnancy and final trimester). However, the prevalence of alcohol and tobacco use prior to and during pregnancy is similar to other national estimates (Muhuri and Gfroerer

2009; Substance Abuse and Mental Health Services Administration, Office of Applied Studies 2009). Finally, there were limited data collected on stressful life events, and our operationalization may not have comprehensively captured the spectrum of stressors that women experience, particularly across the SES gradient, which might have resulted in misclassification. In addition, this study focused on stressful life events and did not examine chronic or environmental stressors, such as poverty, intimate partner violence, or discrimination.

Conclusion

This study, which uses nationally representative data from a US birth cohort, shows that women's exposure to preconception stressful life events and smoking prior to conception or during pregnancy are important independent risk factors for having a LBW baby. In addition to implementing tobacco screening and cessation services prior to and during pregnancy, the clinical practice paradigm may need to be shifted upstream to the preconception period to reduce the psychosocial and physical effects of exposure to stress over the lifecourse through the appropriate use of behavioral and physical health services. Doing so may ultimately improve the long-term health of women and their children.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

Appendix

Table 4 Results of multinomial logistic regression modeling high birthweight[a] predicted by stressful life events prior to conception, alcohol and tobacco use, maternal health, and sociodemographic factors

	Model 1				Model 2				Model 3			
	AOR	95 % CI		*P* value	AOR	95 % CI		*P* value	AOR	95 % CI		*P* value
Stressful life events												
Stressful life events prior to conception												
None	1.00	Reference			1.00	Reference			1.00	Reference		
Any	**1.28**	**1.01**	**1.62**	*	**1.32**	**1.04**	**1.67**	*	1.21	0.95	1.56	
Stressful Life Events During Pregnancy												
None	1.00	Reference			1.00	Reference			1.00	Reference		
Any	0.64	0.38	1.10		0.69	0.41	1.18		0.81	0.47	1.41	
Alcohol and tobacco use												
Alcohol use												
None					1.00	Reference			1.00	Reference		
In 3 months prior to conception only					1.17	0.98	1.41		1.10	0.90	1.35	
In final 3 months of pregnancy					0.58	0.28	1.20		0.52	0.25	1.09	
Tobacco use												
None					1.00	Reference			1.00	Reference		
In 3 months prior to conception only					1.07	0.82	1.40		1.14	0.87	1.51	

Table 4 (continued)

	Model 1			Model 2			Model 3			
	AOR	95 % CI	*P* value	AOR	95 % CI	*P* value	AOR	95 % CI		*P* value
In final 3 months of pregnancy				**0.40**	**0.26 0.63**	***	**0.39**	**0.24**	**0.64**	***
Obstetric factors										
Pregnancy complications										
None							1.00	Reference		
Any							1.01	0.78	1.30	
Maternal chronic conditions										
None							1.00	Reference		
Any							1.14	0.89	1.44	
Prior child born preterm or SGA										
No							1.00	Reference		
Yes							0.63	0.17	2.38	
Prepregnancy body mass index										
BMI<18.5							0.61	0.28	1.33	
18.5≤BMI<25							1.00	Reference		
25≤BMI<30							**1.47**	**1.13**	**1.91**	**
BMI≥30							**2.19**	**1.68**	**2.84**	***
Unknown							**2.30**	**1.25**	**4.22**	**
Initiation of prenatal care										
In the first trimester							1.00	Reference		
In the second or third trimester							1.06	0.61	1.82	
Did not receive prenatal care							**<0.001**	**<0.001**	**<0.001**	***
Number of children born										
Singleton							1.00	Reference		
Multiple							**<0.001**	**<0.001**	**<0.001**	***
Parity[b]										
Nulliparous							1.00	Reference		
Primiparous							**1.37**	**1.07**	**1.75**	*
Multiparous							**1.47**	**1.12**	**1.93**	**
Maternal sociodemographic factors										
Age (years)										
15–19							1.54	0.99	2.41	
20–24							0.81	0.58	1.13	
25–29							1.00	Reference		
30–34							1.01	0.77	1.33	
35+							1.02	0.72	1.45	
Race/ethnicity										
White (non-Hispanic)							1.00	Reference		
Black (non-Hispanic)							**0.43**	**0.30**	**0.62**	***
Asian/Pacific Islander (non-Hispanic)							**0.45**	**0.32**	**0.65**	***
Other (non-Hispanic)							**0.57**	**0.34**	**0.94**	*
Hispanic							0.79	0.58	1.06	

Table 4 (continued)

	Model 1			Model 2			Model 3		
	AOR	95 % CI	*P* value	AOR	95 % CI	*P* value	AOR	95 % CI	*P* value
Marital status (at birth)									
Married or living with partner							1.00	Reference	
Separated/divorced/ widowed							0.88	0.45 1.73	
Never married							0.94	0.67 1.32	
Health insurance status									
Private only							1.00	Reference	
Any public							0.86	0.62 1.20	
None							0.89	0.51 1.57	
Socioeconomic status									
First quintile (lowest)							0.90	0.56 1.45	
Second quintile							0.79	0.55 1.14	
Third quintile							0.96	0.63 1.47	
Fourth quintile							0.86	0.62 1.20	
Fifth quintile (highest)							1.00	Reference	
Region of residence									
Northeast							1.31	0.97 1.77	
Midwest							1.16	0.86 1.56	
South							1.15	0.87 1.50	
West							1.00	Reference	

Source: 2001 ECLS-B. All models account for complex sampling design of the ECLS-B

AOR adjusted odds ratio, *CI* confidence interval, *SGA* small for gestational age, *BMI* body mass index

[a] Versus normal birthweight

[b] Parity of the mother not including her most recent live birth

*$P<0.05$, ** $P<0.01$, ***$P<0.001$

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