J Behav Med (2022) 45:589–602
https://doi.org/10.1007/s10865-022-00306-5

Perceived social support predicts self-reported and objective health and health behaviors among pregnant women

Amanda M. Mitchell[1] · **Jennifer M. Kowalsky**[2] · **Lisa M. Christian**[3,4] · **Martha A. Belury**[5] · **Rachel M. Cole**[5]

Received: 29 September 2020 / Accepted: 7 March 2022 / Published online: 21 April 2022

Abstract Perinatal health and health behaviors play a crucial role in maternal and neonatal health. Data examining psychosocial factors which predict self-reported health and health behaviors as well as objective indicators downstream of health behaviors among pregnant women are lacking. In this longitudinal study design with 131 pregnant women, perceived social support was examined as a predictor of self-rated health and average levels of sleep quality, health-promoting and health-impairing behaviors, and red blood cell (RBC) polyunsaturated fatty acids across early, mid, and late pregnancy. Participants provided a blood sample and fatty acid methyl esters were analyzed by gas chromatography. Measures included the Multidimensional Scale of Perceived Social Support, Pittsburgh Sleep Quality Index, and Prenatal Health Behavior Scale. Regression models demonstrated that, after adjustment for income, race/ethnicity, age, relationship status, pre-pregnancy body mass index, greater social support was associated with better self-rated health ($p=0.001$), greater sleep quality ($p=0.001$), fewer health-impairing behaviors ($p=0.02$), and higher RBC omega-3 fatty acids ($p=0.003$). Associations among social support with health-promoting behaviors, RBC omega-6 fatty acids, or gestational weight gain were not significant. Findings underscore the benefits of perceived social support in the context of pregnancy. Examination of pathways that link social support with these outcomes will be meaningful in determining the ways in which perinatal psychosocial interventions may promote health.

Keywords Social support · Pregnancy · Health behavior · Sleep · Fatty acids · Weight gain

Amanda M. Mitchell and Jennifer M. Kowalsky contributed equally as first authors.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10865-022-00306-5.

✉ Amanda M. Mitchell
Amanda.Mitchell@louisville.edu

Jennifer M. Kowalsky
kowalsky.9@osu.edu

Lisa M. Christian
lisa.christian@osumc.edu

Martha A. Belury
belury.1@osu.edu

Rachel M. Cole
cole.311@buckeyemail.osu.edu

[1] Department of Counseling and Human Development, College of Education and Human Development, University of Louisville, Woodford and Harriett Porter Building, 1905 South 1st Street, Louisville, KY 40292, USA

[2] Department of Psychology, The Ohio State University, Newark, OH, USA

[3] Department of Psychiatry &, Behavioral Health, The Ohio State University Wexner Medical Center, Columbus, OH, USA

[4] The Institute for Behavioral Medicine Research, The Ohio State University Wexner Medical Center, Columbus, OH, USA

[5] Department of Human Nutrition, The Ohio State University, Columbus, OH, USA

Introduction

Maternal health behaviors are especially important in pregnancy because they affect not only the self, but also fetal development and neonatal health outcomes. Health behaviors, such as physical activity, nutrition, and substance use, have been shown to influence the risk for pregnancy complications, neurodevelopmental disorders, and adverse birth outcomes (Blair et al., 2015; Dunkel Schetter & Lobel, 2012; Klebanoff et al., 2011; Liu et al., 2008; Lobel et al., 2008). The Centers for Disease Control and Prevention (CDC) and the American Congress of Obstetricians and Gynecologists (ACOG), recommend that pregnant women reduce or avoid some behaviors (e.g., caffeine, alcohol, and tobacco use), adapt their diet (e.g., increasing folic acid intake), adhere to vaccination recommendations, attend regular prenatal care visits, and engage in adequate physical activity (ACOG, 2015; CDC, 2016). Moreover, a growing body of literature indicates that poorer sleep, as measured by duration, quality, and clinical diagnoses, are associated with adverse maternal health (e.g., gestational diabetes) and birth outcomes (e.g., preterm birth; Blair et al., 2015; Carroll et al., 2019; Christian et al., 2019; Facco et al., 2017; Felder et al., 2017; Micheli et al., 2011; Okun & Coussons-Read, 2007; Okun et al., 2011). In addition to the influence of biological factors (e.g., hormones; Lee et al., 2000; Sowers et al., 2008), sleep hygiene (e.g., routines, electronic devise use) and other health behaviors (e.g., physical activity; Bacaro et al., 2020) contribute to sleep quality in pregnancy. Accordingly, sleep is largely recognized as a health behavior pathway in perinatal health models (Christian, 2015; Dunkel Schetter, 2011). Finally, poorer self-rated health has been associated with increased medical care utilization during pregnancy, increased childbirth complications, and elevated maternal inflammatory markers (Christian et al., 2013; Rodriguez et al., 1999; Stepanikova et al., 2016). Importantly, self-rated health may capture the broader context of one's experience of their health and health behaviors (Bombak, 2013).

Dietary choices illustrate one parameter of health behaviors and clearly impact maternal and neonatal health. Consideration of objective health indicators downstream from health behaviors provides an additional layer in understanding one's health. One such indicator relevant for fetal development and neonatal health is polyunsaturated fatty acids (PUFAs); omega-3 and omega-6 PUFAs. Two PUFAs, alpha-linolenate and linoleate are essential in the diet since they cannot be endogenously produced. Therefore, blood levels are good indicators of dietary intake (Sun et al., 2007). These fatty acids and their metabolites play critical roles in metabolism (Saini & Keum, 2018). Consumption of omega-3 PUFAs reduce the likelihood of preterm birth and are beneficial for fetal growth (Grootendorst-van Mil et al., 2018; Innis, 2007; Lauritzen et al., 2001; Middleton et al., 2018). The roles of omega-6 PUFAs in pregnancy are less explicit; however, some data have linked greater self-reported omega-6 PUFAs in the diet with adverse birth outcomes, using the one-day 24-h recall method (Lee et al., 2018). In addition to PUFAs, total gestational weight gain is important in perinatal health. Depending on pre-pregnancy body mass index (BMI), recommendations for healthy weight gain range from 11 to 40 pounds by the end of pregnancy (ACOG, 2013). In a prior study of 1950 women, only 17.3% achieved the recommended gestational weight gain, per the Institute of Medicine guidelines, with most women gaining more weight than was suggested (Chung et al., 2013). This is relevant as insufficient or excessive weight gain increases the risk for adverse maternal and fetal outcomes, such as preeclampsia and large for gestational age (Kiel et al., 2007; Stotland et al., 2006).

Pregnancy can provide unique motivation for health behavior change. Prospective studies from pre-pregnancy to the perinatal period have documented positive changes for some health behaviors (e.g., reducing caffeine and alcohol intake, smoking cessation or reduction, improving diet) and limited change for others (e.g., diet; Crozier et al., 2009; Lee et al., 2016; Malek et al., 2016). In an epidemiological survey, fruit and vegetable intake remained unchanged from pre-pregnancy to early pregnancy and late pregnancy, with nearly half of pregnant women not meeting the recommended 5 serving minimum (Crozier et al., 2009). In a separate study, moderate physical activity declined among women from pre-pregnancy to the second trimester (Pereira et al., 2007). While access to resources (e.g., income to purchase fruits and vegetables) is crucial to consider when contextualizing health behaviors and health behavior change (Crozier et al., 2009; Malek et al., 2016); identifying interpersonal predictors of health and health behaviors in pregnancy also provides an opportunity to inform interventions.

One key relational factor that may affect health and health behaviors is social support. A substantial literature base has examined the effects of social support on maternal psychological distress and birth outcomes (Dunkel Schetter, 2011; Lancaster et al., 2010; Littleton et al., 2007; Yim et al., 2015). Across systematic reviews and a meta-analysis, greater social support has been linked with reduced psychological distress during both pregnancy and postpartum (Lancaster et al., 2010; Littleton et al., 2007; Yim et al., 2015). Although mixed findings have been reported regarding direct associations between social support and birth outcomes, data suggest that social support may serve a protective role in the relationship between stress with preterm birth as well as birth weight (Dunkel Schetter, 2011; Shapiro et al., 2013). In any case, data demonstrate that social support is important to consider in the context of perinatal health.

In addition to affecting stress and birth outcomes, social support can influence perinatal health and health behaviors.

This is consistent with proposed relationships in perinatal health models (Christian, 2015; Dunkel Schetter, 2011). Moreover, studies have shown that greater social support is linked to greater exercise frequency, healthier eating habits, and reduced cigarette smoking among perinatal women (Elsenbruch et al., 2006; Fowles et al., 2012; Harley & Eskenazi, 2006; Jesse et al., 2006; Thornton et al., 2006). However, this body of literature is limited by its emphasis on singular health behaviors and self-report measures of health and health behaviors. Psychosocial predictors of health-promoting and health-impairing behaviors may vary, including in pregnancy (e.g., Auerbach et al., 2014). Examination of social support with both health-promoting and health-impairing behaviors, as well as expanding our conceptualization of health and health behavior to include sleep and self-rated health, has the potential to better inform research on multiple health behavior change (Prochaska et al., 2008). In addition, the inclusion of objective health indicators downstream from health behaviors will strengthen our understanding of one's health.

The current analyses sought to extend the current literature by examining perceived social support as a predictor of self-rated health, sleep (i.e., average levels of sleep quality across early, mid, and late pregnancy), self-reported health behavior across pregnancy (i.e., average levels of health-promoting and health-impairing behaviors across early, mid, and late pregnancy), and objective indicators of health across pregnancy (i.e., average levels of omega-3 and omega-6 PUFAs across early, mid, and late pregnancy and weight gain from pre-pregnancy to last maternal weight recorded prior to birth) among 131 pregnant women. It was hypothesized that greater perceived social support would be linked with better self-rated health, better sleep quality, greater engagement in health-promoting behaviors (e.g., exercise, healthy diet), less engagement in health-impairing behaviors (e.g., smoking, caffeine use), more favorable RBC PUFA status, and healthier gestational weight gain.

Method

Study design and participants

Data were collected as part of a broader prospective study examining stress and immune adaptation among 144 Black and white women across pregnancy and early postpartum. Women were recruited from the Ohio State University Wexner Medical Center (OSUWMC) and the community of Columbus, Ohio. Women completed study visits from 2009 to 2014 which included psychosocial assessments and blood sampling in early, mid, and late pregnancy as well as postpartum. Exclusion criteria included any known fetal anomaly, illicit drug use, consumption of more than two alcoholic drinks per week during pregnancy (per self-report or medical record), or major immunological or endocrine conditions (e.g., rheumatoid arthritis, hypothyroidism) due to implications for immune adaptation. Written informed consent was obtained at the first study visit, and participants received modest financial compensation upon completion of each visit. The study was approved by the Ohio State University Biomedical Institutional Review Board. Primary analyses of the broader study with subsamples or the full cohort have been published. Of the constructs included in the current analyses, one prior study has examined social support as a predictor of telomere length in a subsample of this cohort (Mitchell et al., 2018). Other studies have included RBC PUFA status (Christian et al., 2016), gestational weight gain (Jara et al., 2020), or sleep (Blair et al., 2015, Christian et al., 2016, 2018, 2019, 2021) in relation to other constructs in subsamples or the full cohort.

The current secondary analysis focused on data from early (mean = 12.5 weeks, SD = 1.89), mid (mean = 22.06 weeks, SD = 2.15), and late (mean = 30.73 weeks, SD = 2.02) pregnancy. Data from the postpartum visit were not necessary to address the current hypotheses. Most constructs of focus were measured at all three visits and aggregated to describe experiences, on average, across pregnancy: sleep, health-promoting behaviors, health-impairing behaviors, and RBC PUFA status. There were three exceptions to measurement at each time point. First, the independent variable of social support was only assessed in late pregnancy for the full cohort. However, perceived social support is generally considered a stable construct formulated by early life relationships (Uchino, 2009). Second, gestational weight gain was calculated with two points of measurement: pre-pregnancy weight and last weight prior to delivery. Third, self-rated health was only assessed in early pregnancy. Participants were excluded from current analyses if they did not complete the social support scale due to missing the late pregnancy study visit at which this was administered ($n = 13$), resulting in a final analytic sample of 131.

Demographics

Maternal age, race/ethnicity, annual household income, education level, relationship status, and number of prior births (parity) were collected by self-report at the early pregnancy visit. Pre-pregnancy body mass index (BMI; kg/m^2) was calculated using self-reported pre-pregnancy weight and measured height at the early pregnancy visit.

Self-report measures

Social support

Perceived social support was measured using the Multidimensional Scale of Perceived Social Support (MSPSS) administered at the late pregnancy visit (Zimet et al., 1988). This 12-item, 7-point scale (very strongly disagree to very strongly agree) assesses perceived social support from family, friends, and a special person (boyfriend, husband, or other romantic partner), with scale items such as "I get the emotional help and support I need from my family". This scale has demonstrated strong internal consistency (α = 0.88) and test–retest reliability (α = 0.85), and good construct validity for use with pregnant women (Zimet et al., 1988, 1990). The original scale instructions ask about support from a "special person"; however, research has shown that a high percentage of people think of children, friends, or family members, in addition to romantic partners, as their "special person" (Prezza & Giuseppina Pacilli, 2002). As such, the language in MSPSS was adapted to include clarification of special person as "husband, boyfriend, or other romantic partner". The total score for this measure was used in analyses. For participants who reported single as their relationship status, their scores on the special person subscale were retained in the total with the expectation that rating "strongly disagree" to receiving support from a romantic partner was still relevant.

Self-rated health

Global self-rated health was assessed at the early pregnancy visit using a single item "In general, would you say your health is: excellent; very good; good; fair; or poor," with lower ratings indicating better self-rated health. Drawn from the RAND Health Survey, this measure has demonstrated predictive validity for cardiovascular events and all-cause mortality (DeSalvo et al., 2006; Idler & Benyamini, 1997; Ware & Sherbourne, 1992). In pregnancy, it has been linked with elevated inflammatory markers and childbirth complications (Christian et al., 2013; Stepanikova et al., 2016).

Sleep quality

Sleep quality was measured in early, mid, and late pregnancy using the Pittsburgh Sleep Quality Index (PSQI). A score > 5 is indicative of clinically disturbed sleep, and has shown high sensitivity and specificity in identifying good and poor sleepers (Buysse et al., 1989). This self-report measure includes seven subscales: subjective sleep quality, sleep latency (i.e., time to fall asleep), sleep duration, habitual sleep efficiency (i.e., time asleep/time in bed * 100), sleep disturbance (i.e., trouble sleeping due to disruptions such as temperature and bathroom use), use of sleeping medications, and daytime dysfunction. Previous research has demonstrated strong test–retest reliability and predictive validity for health outcomes associated with pregnancy (Backhaus et al., 2002; Skouteris et al., 2009).

Prenatal health behaviors

Maternal prenatal health behaviors were assessed in early, mid, and late pregnancy using the Prenatal Health Behavior Scale (PHBS) (Lobel, 1996). Based on factor analysis, two subscales have been recommended consisting of an 8-item subscale assessing health-promoting behaviors (exercise for at least 15 min; get enough sleep; drink milk, eat dairy products or take a calcium supplement; take vitamins; eat enough food to satisfy your hunger; eat high fiber foods such as whole grain breads or cereals; drink enough fluids; eat a balanced diet, including fruit and vegetables) and a 7-item subscale for health-impairing behaviors (smoke cigarettes; skip a meal such as breakfast or lunch; eat snack foods instead of a regular meal; stand on your feet for long periods of time; drink things with caffeine such as coffee or colas; lift heavy objects or do lots of bending; overstretch or twist your body; Auerbach et al., 2014). The frequency of behaviors over the previous two weeks was measured using a 5-point scale ranging from never to very often. Within the present sample, the health-promoting subscale demonstrated good reliability across pregnancy (α = 0.64–0.68) and the health-impairing subscale had adequate reliability across pregnancy (α = 0.54–0.58), consistent with previous research with pregnant women (Auerbach et al., 2014).

Red blood cell (RBC) polyunsaturated fatty acids (PUFA)

Blood samples were obtained in early, mid, and late pregnancy via venipuncture and each RBC PUFA sample was collected in a 6 mL EDTA tube on ice. The sample was centrifuged at 1932 g for 10 min, the plasma was removed, and the RBCs were stored in 1 mL cryovials. Samples were stored at − 80 °C until the time of assay. Lipids were extracted and methylated from RBC samples using boron-trifluoride in methanol (Harris et al., 2008; Pottala et al., 2012). Fatty acid methyl esters were analyzed by gas chromatography (Shimadzu, Columbia, MD) using a 30-m Omegawax 320 (Supelco-Sigma) capillary column. The helium flow rate was 30 mL/min and oven temperature began at 175 °C for 4 min then increased to 220 °C at a rate of 3 °C/min as previously described (Belury & Kempa-Steczko, 1997). Retention times were compared to authentic standards for fatty acid methyl esters (Supelco-Sigma, St. Louis, MO and Matreya, Inc., Pleasant Gap, PA) and fatty acids are reported as percent of total identified. For calculating total ω-3 fatty acids, 18:3n3 (alpha-linolenate), 20:5n3 (eicosapentaenoate), 22:5n3 (docosapentaenoate), and 22:6n3 (docosahexaenoate) were summed. Similarly, for calculating total ω-6 fatty acids, 18:2n6 (linoleate), 20:2n6 (eicosadienoate), 20:3n6 (dihomo-gamma-linoleate), 20:4n6 (arachidonate), 22:4n6 (adrenate), and 22:5n6 (docosapentaenoate) were summed.

Gestational weight gain

Gestational weight gain was calculated using self-reported pre-pregnancy weight in the early pregnancy visit and last maternal weight prior to birth collected via medical record review.

Statistical analyses

All analyses were conducted in SPSS 26.0. The PHBS was added to the study after data collection was underway and some women were missing gestational weight gain in their medical records, therefore responses for 20 and 12 women were not included in such models, respectively. Descriptive statistics were calculated for all participants. To reflect average self-reported health and health behaviors across pregnancy, mean scores for sleep quality, health-promoting and health-impairing behaviors, omega-3, and omega-6, were calculated. Assumptions were assessed using histograms, P-P plots, and residual scatter plots. Standardized and studentized residuals (> 3 or < 3) as well as Cook's Distance (> 1) were used to determine outliers (Osborne & Overbay, 2004). Standardized or studentized residual outliers were detected in models with sleep quality (n = 1) and weight gain (n = 1). Results were not meaningful changed when these outliers were individually excluded from models; thus, these participants were retained in reported analyses.

Because perceived social support was negatively skewed, Spearman's correlations were utilized to examine associations of social support with self-reported and objective health and health behaviors. A series of hierarchical linear regression analyses were conducted to predict self-rated health, sleep quality (per PSQI total score), health-promoting behaviors and health-impairing behaviors (per subscale scores on the PHBS), RBC levels of omega-3 and omega-6 fatty acids, and gestational weight gain. Income, race/ethnicity, maternal age, relationship status, and pre-pregnancy BMI were entered into the first block of each analysis as covariates. Income and education were included in models as described in Table 1. Race/ethnicity (Black, White, Multiracial/Hispanic), relationship status (single, in a relationship/married), and pre-pregnancy BMI (underweight/normal weight, overweight/obese) were recoded in order to interpret model parameters. Perceived social support was entered into the second block to assess if it served as an independent predictor. Exploratory analyses using source of social support as a predictor (family, friends, special person), as opposed to the total social support score, were conducted, and are reported in supplementary materials (Appendix).

Table 1 Descriptive statistics for demographic characteristics

Maternal age (years)	24.8 (4.1)
Race	
Black	71 (54.2%)
White	53 (40.5%)
Multiracial	3 (2.3%)
Ethnicity	
Hispanic	5 (3.8%)
Not hispanic	126 (96.2%)
Relationship status	
Single	24 (18.3%)
In a relationship	68 (51.9)
Married	39 (29.8)
Annual income	
< $15,000	59 (45%)
$15,000–$29,999	34 (26%)
≥ $30,000	38 (29%)
Education	
Some high school	19 (14.5%)
High school graduate	31 (23.7%)
Some college	52 (39.7%)
College graduate	29 (22.1%)
Pre-pregnancy BMI (kg/m^2)	28.1 (6.8)
Underweight	3 (2.3%)
Normal weight	47 (35.9%)
Overweight	38 (29.0%)
Obese	43 (32.8)
Parity	
Nulliparous	30 (22.9%)
Primiparous	50 (38.2%)
Multiparous	51 (38.8%)

Data are reported in Mean (SD) or *n* (%). *n* = 131

Results

Sample characteristics

As detailed in Table 1, the present sample was on average 24.8 years of age (SD = 4.1, range = 18–33) and identified as Black (54.2%), White (40.5%), multiracial (2.3%), and/or Hispanic (3.8%). The majority of participants were in a relationship or married (81.7%) and reported an annual household income of less than $30,000 (71%). The average pre-pregnancy BMI for the sample was 28.1 kg/m^2 (SD = 6.8), with 61.8% of participants reporting a weight consistent with overweight or obese status. Descriptive statistics for

Table 2 Descriptive statistics for social support, health behaviors, and health indicators

MSPSS: Social support	66.67 (16.44) 12–84
Self-rated health[a]	2.36 (0.84) 1–4
PSQI: Sleep quality[b]	6.79 (3.10) 0.67–16.00
PHBS: Health-promoting behaviors	22.78 (4.22) 13–31.33
PHBS: Health-impairing behaviors	9.40 (4.08) 0.33–20.50
ω-3 fatty acids	5.51 (0.82) 3.63–8.08
ω-6 fatty acids	36.90 (1.68) 32.44–40.27
Gestational weight gain (lbs)	29.95 (14.99) −14.00–69.90

Data are reported in Mean (SD), range

[a]Higher scores reflect poorer health

[b]Higher scores reflect poorer sleep quality

MSPSS: Multidimensional Scale of Perceived Social Support; PHBS: Prenatal Health Behavior Scale; PSQI: Pittsburgh Sleep Quality Index. Fatty acids are reported as percent of total identified. For calculating total ω-3 fatty acids, 18:3n3 (alpha-linolenate), 20:5n3 (eicosapentaenoate), 22:5n3 (docosapentaenoate), and 22:6n3 (docosahexaenoate) were summed. For calculating total ω-6 fatty acids, 18:2n6 (linoleate), 20:2n6 (eicosadienoate), 20:3n6 (dihomo-gamma-linoleate), 20:4n6 (arachidonate), 22:4n6 (adrenate), and 22:5n6 (docosapentaenoate) were summed. *n's* = 111–131

perceived social support, self-reported health behaviors, and objective health indicators are presented in Table 2.

Correlations of perceived social support with health indicators

Spearman correlations were used to assess relationships of perceived social support with both self-reported (self-rated health, sleep quality, health-promoting behaviors, health-impairing behaviors) and objective (RBC fatty acid status and gestational weight gain) health and health behaviors. As shown in Table 3, greater social support, per total score on the MSPSS, was significantly associated with greater self-rated health ($r = -0.34$, $p < 0.001$), better sleep quality per total score on PSQI ($r = -0.35$, $p < 0.001$), greater engagement in health-promoting behaviors ($r = 0.23$, $p = 0.017$), and lower engagement in health-impairing behaviors ($r = -0.32$, $p = 0.001$). In addition, greater social support was related to higher RBC omega-3 levels ($r = 0.35$, $p < 0.001$), and greater gestational weight gain ($r = 0.22$, $p = 0.015$). No significant association emerged between perceived social support and RBC omega-6 levels ($r = -0.13$, $p = 0.14$).

Independent effects of perceived social support on health indicators

Next, to determine the independent predictive value of social support after accounting for key covariates, hierarchical linear regression analyses were conducted. Covariates were consistent across analyses and included in step one of regression models: income, race/ethnicity, maternal age, relationship status, and pre-pregnancy BMI. Detailed test statistics for each step of the linear regression analyses are presented in Tables 4 & 5.

Table 3 Spearman correlations between perceived social support, health, and health behaviors during pregnancy

	Self-report health indicators				Objective health indicators		
	Self-rated health	Sleep quality	Health promoting	Health impairing	Omega-3	Omega-6	Weight Gain
Social support	−0.34***	−0.35***	0.23*	−0.32**	0.35***	−0.13	0.22*
Self-rated health	–	0.33***	−0.15	0.15	−0.07	−0.05	0.001
Sleep Quality		–	−0.38***	0.15	−0.06	0.05	−0.01
Health promoting			–	−0.40***	0.30**	−0.16	0.23*
Health impairing				–	−0.34***	0.34***	−0.14
Omega-3					–	−0.41***	0.06
Omega-6						–	−0.13

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; Self-rated health: Higher scores reflect poorer health; Sleep quality: Higher scores reflect poorer sleep quality. *n*'s = 100–131

Table 4 Regression models predicting prenatal health behaviors, self-rated health, and sleep quality

Full model statistics	Self-rated Health	Sleep Quality	Health Promoting Behaviors	Health Impairing Behaviors
	$F(7, 123)=2.64$, $p=0.014$, $R^2=0.13$, $\Delta R^2=0.08$, $\Delta F=11.45$**	$F(7, 123)=2.25$, $p=0.034$, $R^2=0.11$, $\Delta R^2=0.09$, $\Delta F=12.23$**	$F(7, 103)=3.76$, $p=0.001$, $R^2=0.20$, $\Delta R^2=0.02$, $\Delta F=2.92$	$F(7, 103)=3.61$, $p=0.002$, $R^2=0.20$, $\Delta R^2=0.04$, $\Delta F=5.22$*
Step 1	β	β	β	β
Income	−0.17	−0.11	0.07	−0.31**
Race/Ethnicity[a]	−0.01	0.09	−0.29**	−0.02
Race/Ethnicity[b]	0.13	0.07	0.07	0.07
Maternal Age	0.06	0.05	0.24*	−0.09
Relationship Status[c]	0.16	0.02	−0.02	−0.06
Pre-pregnancy BMI	0.06	−0.07	−0.05	0.05
Step 2				
Income	−0.14	−0.08	0.05	−0.28*
Race/Ethnicity[a]	−0.03	0.07	−0.29**	−0.03
Race/Ethnicity[b]	0.13	0.06	0.08	0.07
Maternal age	0.06	0.04	0.25*	−0.10
Relationship status[c]	0.23*	0.09	−0.05	−0.02
Pre-pregnancy BMI	0.04	−0.09	−0.04	0.05
Social support	−0.30**	−0.31**	0.16	−0.21*

*$p<0.05$; **$p<0.01$; Self-rated health: Higher scores reflect poorer health; Sleep quality: Higher scores reflect poorer sleep quality; BMI: Body mass index, 0 = Not overweight or obese, 1 = Overweight or obese

[a]0 = Not Black, 1 = Black

[b]0 = Not multiracial and/or Hispanic, 1 = Multiracial and/or Hispanic

[c]0 = Single, 1 = In relationship or married. n's = 111–131

Self-rated health

As expected, after inclusion of specified covariates, greater perceived social support predicted better self-rated health ($\beta=-0.30$, $p=0.001$).

Sleep quality

Consistent with the previous analysis, perceived social support (per MSPSS total score) was a significant predictor of PSQI total scores, with greater social support predicting lower PSQI scores, indicating better sleep quality ($\beta=-0.31$, $p=0.001$).

Health behaviors

After controlling for the covariates, the association between perceived social support (per MSPSS total score) and health-promoting behaviors was not statistically significant ($\beta=0.16$, $p=0.09$). As predicted, the relationship between greater perceived social support and fewer health-impairing behaviors remained significant after accounting for covariates ($\beta=-0.21$, $p=0.024$).

Red blood cell (RBC) polyunsaturated fatty acids

Consistent with expectations, after accounting for the covariates, greater social support predicted higher RBC omega-3 fatty acid levels ($\beta=0.24$, $p=0.003$). The relationship between perceived social support and RBC omega-6 fatty acid levels was not significant ($\beta=-0.05$, $p=0.572$).

Gestational weight gain

After inclusion of covariates, the association between perceived social support and gestational weight gain was not significant ($\beta=0.16$, $p=0.098$).

Supplementary analyses

Analyses using source of social support as a predictor (family, friends, special person) showed that after controlling for covariates, family social support was a significant predictor of a greater number of indicators of health and health behaviors than friends or special person subscales (Appendix).

Table 5 Regression models predicting objective health indicators

Full model statistics	Omega-3	Omega-6	Gestational Weight Gain
	F(7, 123) = 6.67, p < 0.001, R^2 = 0.28, ΔR^2 = 0.05, ΔF = 9.05**	F(7, 123) = 6.05, p < 0.001, R^2 = 0.26, ΔR^2 = 0.002, ΔF = 0.32	F(7, 111) = 1.99, p = 0.063, R^2 = 0.11, ΔR^2 = 0.02, ΔF = 2.78
Step 1	β	β	β
Income	0.33**	− 0.20*	0.13
Race/Ethnicity[1]	− 0.06	0.32***	− 0.08
Race/Ethnicity[2]	0.01	0.06	0.12
Maternal age	0.22*	− 0.27**	− 0.08
Relationship status[3]	− 0.06	0.13	− 0.07
Pre-pregnancy BMI	− 0.08	0.06	− 0.19*
Step 2			
Income	0.31**	− 0.19*	0.11
Race/Ethnicity[a]	− 0.04	0.32***	− 0.07
Race/Ethnicity[b]	0.01	0.06	0.12
Maternal age	0.22*	− 0.27**	− 0.08
Relationship status[c]	− 0.11	0.14	− 0.11
Pre-pregnancy BMI	− 0.06	0.05	− 0.18
Social support	0.24**	− 0.05	0.16

*p < 0.05; **p < 0.01; ***p < 0.001; BMI: Body mass index, 0 = Not overweight or obese, 1 = Overweight or obese

[a]0 = Not Black, 1 = Black

[b]0 = Not multiracial and/or Hispanic, 1 = Multiracial and/or Hispanic

[c]0 = Single, 1 = In relationship or married. n's = 119–131

Discussion

This study examined associations of perceived social support with self-reported and objective health and health behaviors among pregnant women. Results demonstrated that greater perceived social support was associated with better self-rated health, greater sleep quality, and fewer health-impairing behaviors (e.g., smoking use, skipping meals, caffeine consumption). Although a significant positive relationship emerged between social support with self-reported health-promoting behaviors and gestational weight gain in correlations, these associations were no longer significant after adjusting for covariates in the first step of regression models, with significant contributions from age, race/ethnicity, and/or BMI depending on the model. Overall, consistent with prior studies, these findings underscore the benefits of perceived social support on self-reported health and health behaviors (Dunkel Schetter, 2011; Elsenbruch et al., 2006; Fowles et al., 2012; Harley & Eskenazi, 2006; Jesse et al., 2006; Thornton et al., 2006). Literature has shown that poorer self-rated health and health behaviors are linked with adverse perinatal outcomes, including greater psychological distress and serum inflammatory markers, as well as increased risk for preterm birth (Blair et al., 2015; D'Anna-Hernandez et al., 2016; Felder et al., 2017; Jesse et al., 2014; Lobel et al., 2008; Schytt & Hildingsson, 2011; Tomfohr et al., 2015). While data in non-pregnant adults have supported the association between greater social support and better self-reported health indicators (Chung, 2017; DiMatteo, 2004; Park et al., 2004), the current study describes the positive impact of social support on these indicators in the context of pregnancy.

A key strength of this study was the use of objective health indicators downstream from health behaviors in addition to self-report measures. Prior data have linked greater social support with healthy eating habits, as assessed via surveys (Fowles et al., 2012; Harley & Eskenazi, 2006). In the present study, greater perceived social support was associated with higher RBC levels of omega-3 PUFAs. The association between social support with these fatty acid levels may be attributable to better dietary practices, such as greater consumption of foods high in omega-3 PUFAs (e.g., salmon), and/or regular intake of recommended supplements in pregnancy containing the key omega-3 fatty acids of docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA). The inclusion of ecological momentary assessments of eating behaviors in future studies may be informative in elucidating this relationship. In contrast to omega-3 PUFAs, no significant relationship was found between social support and omega-6 PUFAs, which are primarily obtained through the consumption of certain oils and nuts. This may be a reflection of routine health behaviors during pregnancy involving omega-3 fatty acids (e.g., DHA and EPA supplement) but not omega-6 fatty acids. Nevertheless, associations among PUFAs with birth outcomes and neonatal health (Grootendorst-van Mil et al., 2018; Innis, 2007; Lauritzen et al., 2001; Middleton et al., 2018; Qawasmi et al., 2013), including the benefits of arachidonic (omega-6 fatty acid) on visual acuity among infants (Qawasmi et al., 2013), highlight the importance of research to clarify the roles and mechanisms of these fatty acids in perinatal health outcomes.

Perceived social support has been described as a stable construct informed by early life interactions, such as parental affection and familial conflict (Uchino, 2009), and it is likely activated during stress or significant life events. Of note, substantial changes in relationships, psychological distress, and physiological functioning occur during the perinatal period (Christian & Porter, 2014; Dunkel Schetter, 2011; Heron et al., 2004), providing meaningful opportunities for these changes to affect perceived social support and its relationship with health and health behaviors. While the current secondary analyses only included a one-time assessment of perceived social support during pregnancy, future studies carefully considering potential changes over time will significantly contribute to the literature. Theoretical models have posited both direct and indirect pathways linking social support with psychological distress (e.g., pregnancy-specific anxiety), health behaviors, and physiological stress (Christian, 2015; Dunkel Schetter, 2011). Though the current study tested the direct relationships between social support and self-reported health and health behaviors, examinations of comprehensive biopsychosocial models will help identify the underlying mechanisms, or mediators, of these associations (e.g., psychological distress, better dietary practices).

After adjusting for demographic characteristics, perceived social support was no longer significantly associated with self-reported health-promoting behaviors or weight gain. Regression results indicate that specific covariates (i.e., maternal age, race/ethnicity, and pre-pregnancy BMI) played key roles in the first step of these models when compared to models with other outcomes. Furthermore, these variables have been associated with health-promoting behaviors and weight gain in other studies (Brawarsky et al., 2005; Viau et al., 2002). While prior studies and correlations in the current study suggest that perceived social support is meaningful to consider in relation to health-promoting behaviors and weight gain (Omidvar et al., 2018; Thornton et al., 2006), the process by which these relationships are modeled may be influential (e.g., direct versus indirect effects). Associations between social identities with health and health behaviors reflect the ways in which oppression and privilege are embedded into our systems and structures (e.g., disparities in access to healthy foods). Studies which consider social support alongside variables at other levels of influence (e.g., community, societal; National Institute on Minority Health & Health Disparities, 2017) in relation to health and health behaviors will greatly contribute to the literature.

Of note, over 70% of the current study sample described an annual household income of less than $30,000 per year, and the independent contribution of income in models with health behaviors and RBC fatty acids was clearly documented. Economic resources (e.g., food security, access to healthcare), environmental considerations (e.g., greater exposure to pollution), and occupational expectations (e.g., lifting heavy objects, standing versus sitting) play critical roles in whether someone is able to adhere to suggested guidelines for health behaviors (Solar & Irwin, 2010). Consistent with calls in the literature (Tucker et al., 2019), this broader sociopolitical context must be considered as interventions are developed with the intent of targeting psychosocial factors to promote health and well-being.

Social support was operationalized as perceived support from family, friends, and a special person in the current study. Some data suggest type of social support (e.g., emotional, information, religious) may be relevant in elucidating the effects on health and health behaviors (e.g., Debnam et al., 2012; Hetherington et al., 2018). For example, in a sample of 2370 non-pregnant African American adults, greater religious social support was associated with increased fruit and vegetable consumption, greater physical activity, and less alcohol use independent of effects of general social support (Debnam et al., 2012). The degree of ambivalence within relationships is also receiving increasing attention in the literature regarding the link between social processes and health (Uchino, 2012; Uchino et al., 2016). Notably, this concept may not contribute to health behaviors in particular (e.g., Kent et al., 2015). Studies which consider the rich operationalization of social support will be fruitful in elucidating the link between social support and health and health behaviors.

Overall, the consistent relationship between perceived social support with self-reported and objective health and health behaviors warrants attention in the context of perinatal health interventions. Of note, reviews of social support interventions have not yielded promising results in relation to perinatal health outcomes (e.g., Hodnett & Fredericks, 2003; Lu et al., 2005). However, this area of research has been largely described as atheoretical with critical methodological limitations such as missing important pre-intervention assessment information (Dunkel Schetter, 2011), leading to scholars calling for theoretically and methodologically sound intervention investigations (e.g., Hodnett & Fredericks, 2003; Lu et al., 2005). Theoretical models describing the construct of perceived support outline factors that may be informative for intervention development (Uchino, 2009). The early life environment (e.g., familial conflict, attachment) has been proposed to contribute to "positive psychosocial profiles," consisting of perceptions of support and other related variables like dispositional traits (e.g., neuroticism), social skills, and self-esteem (Uchino, 2009, p. 237). In turn, these variables relate to health via coping mechanisms and health behaviors (Uchino, 2009). This conceptualization of perceived support highlights several points of intervention that may be effective to target in social support interventions with pregnant women.

Limitations

The current study is not without limitations. While the inclusion of RBC fatty acid levels provides a nuanced conceptualization of health and health behaviors, particularly in relation to dietary habits, sleep quality was only captured using the PSQI. The PSQI is a widely used self-report instrument which has demonstrated strong psychometric properties (Mollayeva et al., 2016); however, these data in conjunction with wrist-actigraphy data may provide a more complete picture of sleep patterns. For this secondary analysis, constructs were captured at different time points in pregnancy, and some were measured less than three times in the full cohort (i.e., perceived social support, gestational weight gain, self-rated health). This necessitated the conceptualization of experiences, on average, across pregnancy. Because of this, the present analysis is considered cross-sectional in nature and the corresponding limitations apply (e.g., no causal inferences). Given the dynamic nature of pregnancy and to elucidate the causal contributions of social support on health and health behaviors, future research should model a longitudinal approach. In addition, the support needed, perceived, and received during pregnancy likely varies by person and across time. Future research should take a comprehensive approach in the way social support is operationalized and the frequency with which it is assessed. Finally, this study was focused on the relationship between social support and self-reported or objective health and health behaviors. Theoretical models of health behavior posit a multitude of factors that influence health behaviors, including attitudes, self-efficacy, perceived control, and perceived cultural humility of medical provider (Tucker et al., 2019). The role of social support in the context of health behaviors may be best understood when examined in models with other salient theoretical constructs.

Conclusion

In conclusion, in this sample of pregnant women, perceived social support significantly contributed to self-rated health, sleep quality, health-impairing behaviors, and RBC omega-3 fatty acid levels even after adjustment for key demographic characteristics. While associations between social support and self-reported health-promoting behaviors and gestational weight gain were observed, these were no longer statistically significant after the inclusion of income, race/ethnicity, maternal age, relationship status, and BMI in models. Further, a significant relationship was not found between social support and omega-6 fatty acids. These findings underscore the benefits of greater perceived social support on self-reported and objective indicators of health and health behaviors in pregnancy. Studies examining the psychological, behavioral, and physiological pathways by which social support is associated with these outcomes are warranted. These studies will have clear implications for informing the development of effective perinatal interventions situated in a broader sociopolitical context.

Acknowledgments We appreciate the contributions of our Clinical Research Assistants and students to data collection. We also thank the staff and study participants at the Ohio State University Wexner Medical Center Prenatal Clinic.

Funding This study was supported by NICHD (HD067670, LMC) and NINR (R01NR013661, LMC). The project described was supported by Award Number Grant UL1TR001070 from the National Center for Advancing Translational Sciences.

Declarations

Conflict of interest The authors declare no conflicts of interest.

Ethical approval The study was approved by The Ohio State University Biomedical Institutional Review Board.

Consent for publication These data are not under consideration for publication elsewhere. All authors have contributed significantly to the manuscript and consent to their names on the manuscript.

Human and animal rights The study was approved by The Ohio State University Biomedical Institutional Review Board. Research in the current study did not include animals.

Informed consent We have complied with these ethical standards set forth with this IRB approval, and informed consents were obtained for all participants.

References

ACOG. (2013). Committee opinion no. 548: Weight gain during pregnancy. *Obstetrics & Gynecology, 121*(1), 210–212. https://doi.org/10.1097/01.aog.0000425668.87506.4c

ACOG. (2015). Physical activity and exercise during pregnancy and the postpartum period. Committee Opinion No. 650. *Obstetrics and Gynecology, 126*, 135–142.

Auerbach, M. V., Lobel, M., & Cannella, D. T. (2014). Psychosocial correlates of health-promoting and health-impairing behaviors in pregnancy. *Journal of Psychosomatic Obstetrics & Gynecology, 35*(3), 76–83. https://doi.org/10.3109/0167482X.2014.943179

Bacaro, V., Benz, F., Pappaccogli, A., De Bartolo, P., Johann, A. F., Palagini, L., Lombardo, C., Feige, B., Riemann, D., & Baglioni, C. (2020). Interventions for sleep problems during pregnancy: A systematic review. *Sleep Medicine Reviews, 50*, 101234. https://doi.org/10.1016/j.smrv.2019.101234

Backhaus, J., Junghanns, K., Broocks, A., Riemann, D., & Hohagen, F. (2002). Test–retest reliability and validity of the Pittsburgh Sleep Quality Index in primary insomnia. *Journal of Psychosomatic Research, 53*(3), 737–740. https://doi.org/10.1016/S0022-3999(02)00330-6

Belury, M. A., & Kempa-Steczko, A. (1997). Conjugated linoleic acid modulates hepatic lipid composition in mice. *Lipids, 32*, 199–204. https://doi.org/10.1007/s11745-997-0025-0

Blair, L., Porter, K., Leblebicioglu, B., & Christian, L. (2015). Poor sleep quality and associated inflammation predict preterm birth: Heightened risk among African Americans. *Sleep, 38*(8), 1259–1267. https://doi.org/10.5665/sleep.4904

Bombak, A. E. (2013). Self-rated health and public health: A critical perspective. *Frontiers in Public Health, 1*, 1–4. https://doi.org/10.3389/fpubh.2013.00015

Brawarsky, P., Stotland, N., Jackson, R., Fuentes-Afflick, E., Escobar, G., Rubashkin, N., & Haas, J. (2005). Pre-pregnancy and pregnancy-related factors and the risk of excessive or inadequate gestational weight gain. *International Journal of Gynecology & Obstetrics, 91*(2), 125–131. https://doi.org/10.1016/j.ijgo.2005.08.008

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. *Psychiatry Research, 28*(2), 193–213. https://doi.org/10.1016/0165-1781(89)90047-4

Carroll, J. E., Teti, D. M., Hall, M. H., & Christian, L. M. (2019). Maternal sleep in pregnancy and postpartum part II: Biomechanisms and intervention strategies. *Current Psychiatry Reports, 21*, 19. https://doi.org/10.1007/s11920-019-1000-9

CDC. (2016). During pregnancy. Retrieved from http://www.cdc.gov/pregnancy/during.html

Christian, L. M. (2015). Stress and immune function during pregnancy: An emerging focus in mind-body medicine. *Current Directions in Psychological Science*, *24*(1), 3–9.

Christian, L. M., Blair, L. M., Porter, K., Lower, M., Cole, R. M., & Belury, M. A. (2016). Polyunsaturated fatty acid (PUFA) status in pregnant women: Associations with sleep quality, inflammation, and length of gestation. *PloS One*, *11*(2), e0148752.

Christian, L. M., Carroll, J. E., Teti, D. M., & Hall, M. H. (2019). Maternal sleep in pregnancy and postpartum part i: Mental, physical, and interpersonal consequences. *Current Psychiatry Reports, 21*, 1–8. https://doi.org/10.1007/s11920-019-0999-y

Christian, L. M., Carroll, J. E., Porter, K., & Hall, M. H. (2019). Sleep quality across pregnancy and postpartum: Effects of parity and race. *Sleep Health*, *5*(4), 327–334.

Christian, L. M., Iams, J., Porter, K., & Leblebicioglu, B. (2013). Self-rated health among pregnant women: Associations with objective health indicators, psychological functioning, and serum inflammatory markers. *Annals of Behavioral Medicine, 46*(3), 295–309. https://doi.org/10.1007/s12160-013-9521-7

Christian, L. M., Kowalsky, J. M., Mitchell, A. M., & Porter, K. (2018). Associations of postpartum sleep, stress, and depressive symptoms with LPS-stimulated cytokine production among African American and White women. *Journal of Neuroimmunology*, *316*, 98–106.

Christian, L. M., & Porter, K. (2014). Longitudinal changes in serum proinflammatory markers across pregnancy and postpartum: Effects of maternal body mass index. *Cytokine, 70*(2), 134–140. https://doi.org/10.1016/j.cyto.2014.06.018

Christian, L. M., Webber, S., Gillespie, S., Strahm, A. M., Schaffir, J., Gokun, Y., & Porter, K. (2021). Maternal depressive symptoms, sleep, and odds of spontaneous early birth: Implications for racial inequities in birth outcomes. *Sleep*. https://doi.org/10.1093/sleep/zsab133

Chung, J. (2017). Social support, social strain, sleep quality, and actigraphic sleep characteristics: Evidence from a national survey of US adults. *Sleep Health, 3*(1), 22–27. https://doi.org/10.1016/j.sleh.2016.10.003

Chung, J. G., Taylor, R. S., Thompson, J. M., Anderson, N. H., Dekker, G. A., Kenny, L. C., & McCowan, L. M. (2013). Gestational weight gain and adverse pregnancy outcomes in a nulliparous cohort. *European Journal of Obstetrics & Gynecology and Reproductive Biology, 167*(2), 149–153. https://doi.org/10.1016/j.ejogrb.2012.11.020

Crozier, S. R., Robinson, S. M., Borland, S. E., Godfrey, K. M., Cooper, C., & Inskip, H. M. (2009). Do women change their health behaviours in pregnancy? Findings from the Southampton Women's Survey. *Paediatric and Perinatal Epidemiology, 23*(5), 446–453. https://doi.org/10.1111/j.1365-3016.2009.01036.x

D'Anna-Hernandez, K. L., Garcia, E., Coussons-Read, M., Laudenslager, M. L., & Ross, R. G. (2016). Sleep moderates and mediates the relationship between acculturation and depressive symptoms in pregnant Mexican-American women. *Maternal and Child Health Journal, 20*, 422–433. https://doi.org/10.1007/s10995-015-1840-9

Debnam, K., Holt, C. L., Clark, E. M., Roth, D. L., & Southward, P. (2012). Relationship between religious social support and general social support with health behaviors in a national sample of African Americans. *Journal of Behavioral Medicine, 35*, 179–189. https://doi.org/10.1007/s10865-011-9338-4

DeSalvo, K. B., Bloser, N., Reynolds, K., He, J., & Muntner, P. (2006). Mortality prediction with a single general self-rated health question. *Journal of General Internal Medicine, 21*, 267–275. https://doi.org/10.1111/j.1525-1497.2005.00291.x

DiMatteo, M. R. (2004). Social support and patient adherence to medical treatment: A meta-analysis. *Health Psychology, 23*(2), 207–218. https://doi.org/10.1037/0278-6133.23.2.207

Dunkel Schetter, C. (2011). Psychological science on pregnancy: Stress processes, biopsychosocial models, and emerging research issues. *Annual Review of Psychology, 62*, 531–558. https://doi.org/10.1146/annurev.psych.031809.130727

Dunkel Schetter, C., & Lobel, M. (2012). Pregnancy and birth outcomes: A multilevel analysis of prenatal maternal stress and birth weight. In A. Baum, T. A. Revenson, & J. Singer (Eds.), *Handbook of health psychology* (pp. 431–463). Psychology Press.

Elsenbruch, S., Benson, S., Rücke, M., Rose, M., Dudenhausen, J., Pincus-Knackstedt, M. K., Klapp, B. F., & Arck, P. C. (2006). Social support during pregnancy: Effects on maternal depressive symptoms, smoking and pregnancy outcome. *Human Reproduction, 22*(3), 869–877. https://doi.org/10.1093/humrep/del432

Facco, F. L., Grobman, W. A., Reid, K. J., Parker, C. B., Hunter, S. M., Silver, R. M., Basner, R. C., Saade, G. R., Pien, G. W., Manchanda, S., & Louis, J. M. (2017). Objectively measured short sleep duration and later sleep midpoint in pregnancy are associated with a higher risk of gestational diabetes. *American Journal of Obstetrics and Gynecology, 217*, 447-e1.

Felder, J. N., Baer, R. J., Rand, L., Jelliffe-Pawlowski, L. L., & Prather, A. A. (2017). Sleep disorder diagnosis during pregnancy and risk of preterm birth. *Obstetrics & Gynecology, 130*(4), 573–581. https://doi.org/10.1016/j.ajog.2017.05.066

Fowles, E. R., Stang, J., Bryant, M., & Kim, S. (2012). Stress, depression, social support, and eating habits reduce diet quality in the first trimester in low-income women: A pilot study. *Journal of the Academy of Nutrition and Dietetics, 112*(10), 1619–1625. https://doi.org/10.1016/j.jand.2012.07.002

Grootendorst-van Mil, N. H., Tiemeier, H., Steenweg-de Graaff, J., Koletzko, B., Demmelmair, H., Jaddoe, V. W., Steegers, E. A., & Steegers-Theunissen, R. P. (2018). Maternal plasma n-3 and n-6 polyunsaturated fatty acids during pregnancy and features of fetal health: Fetal growth velocity, birth weight and duration of pregnancy. *Clinical Nutrition, 37*(4), 1367–1374. https://doi.org/10.1016/j.clnu.2017.06.010

Harley, K., & Eskenazi, B. (2006). Time in the United States, social support and health behaviors during pregnancy among women of Mexican descent. *Social Science & Medicine, 62*(12), 3048–3061. https://doi.org/10.1016/j.socscimed.2005.11.036

Harris, W. S., Lemke, S. L., Hansen, S. N., Goldstein, D. A., DiRienzo, M. A., Su, H., Nemeth, M. A., Taylor, M. L., Ahmed, G., & George, C. (2008). Stearidonic acid-enriched soybean oil increased the omega-3 index, an emerging cardiovascular risk marker. *Lipids, 43*(9), 805–811. https://doi.org/10.1007/s11745-008-3215-0

Heron, J., O'Connor, T. G., Evans, J., Golding, J., Glover, V., & Team, A. S. (2004). The course of anxiety and depression through pregnancy and the postpartum in a community sample. *Journal of Affective Disorders, 80(1)*, 65–73. https://doi.org/10.1016/j.jad.2003.08.004

Hetherington, E., McDonald, S., Williamson, T., Patten, S. B., & Tough, S. C. (2018). Social support and maternal mental health at 4 months and 1 year postpartum: Analysis from the All Our Families cohort. *Journal of Epidemiology & Community Health, 72*(10), 933–939. https://doi.org/10.1136/jech-2017-210274

Hodnett, E. D., & Fredericks, S. (2003). Support during pregnancy for women at increased risk of low birthweight babies. *Cochrane Database of Systematic Reviews*. https://doi.org/10.1002/14651858.CD000198

Idler, E. L., & Benyamini, Y. (1997). Self-rated health and mortality: A review of twenty-seven community studies. *Journal of Health and Social Behavior, 38*(1), 21–37. https://doi.org/10.2307/2955359

Innis, S. M. (2007). Dietary (n-3) fatty acids and brain development. *The Journal of Nutrition, 137*(4), 855–859. https://doi.org/10.1093/jn/137.4.855

Jara, A., Dreher, M., Porter, K., & Christian, L. M. (2020). The association of maternal obesity and race with serum adipokines in pregnancy and postpartum: Implications for gestational weight gain and infant birth weight. *Brain, Behavior, & Immunity-Health*, *3*, 100053.

Jesse, D. E., Graham, M., & Swanson, M. (2006). Psychosocial and spiritual factors associated with smoking and substance use during pregnancy in African American and White low-income women. *Journal of Obstetric, Gynecologic, & Neonatal Nursing, 35*(1), 68–77. https://doi.org/10.1111/j.1552-6909.2006.00010.x

Jesse, D. E., Kim, H., & Herndon, C. (2014). Social support and self-esteem as mediators between stress and antepartum depressive symptoms in rural pregnant women. *Research in Nursing & Health, 37*(3), 241–252. https://doi.org/10.1002/nur.21600

Kent, R. G., Uchino, B. N., Cribbet, M. R., Bowen, K., & Smith, T. W. (2015). Social relationships and sleep quality. *Annals of Behavioral Medicine, 49*(6), 912–917. https://doi.org/10.1007/s12160-015-9711-6

Kiel, D. W., Dodson, E. A., Artal, R., Boehmer, T. K., & Leet, T. L. (2007). Gestational weight gain and pregnancy outcomes in obese women: How much is enough? *Obstetrics & Gynecology, 110*(4), 752–758. https://doi.org/10.1097/01.AOG.0000278819.17190.87

Klebanoff, M. A., Harper, M., Lai, Y., Thorp, J., Jr., Sorokin, Y., Varner, M. W., Wapner, R. J., Caritis, S. N., Iams, J. D., & Carpenter, M. W. (2011). Fish consumption, erythrocyte fatty acids, and preterm birth. *Obstetrics and Gynecology, 117*(5), 1071–1077. https://doi.org/10.1097/AOG.0b013e31821645dc

Lancaster, C. A., Gold, K. J., Flynn, H. A., Yoo, H., Marcus, S. M., & Davis, M. M. (2010). Risk factors for depressive symptoms during pregnancy: A systematic review. *American Journal of Obstetrics and Gynecology, 202*(1), 5–14. https://doi.org/10.1016/j.ajog.2009.09.007

Lauritzen, L. A., Hansen, H. S., Jørgensen, M. H., & Michaelsen, K. F. (2001). The essentiality of long chain n-3 fatty acids in relation to development and function of the brain and retina. *Progress in Lipid Research, 40*(1–2), 1–94. https://doi.org/10.1016/s0163-7827(00)00017-5

Lee, A., Belski, R., Radcliffe, J., & Newton, M. (2016). What do pregnant women know about the healthy eating guidelines for pregnancy? A web-based questionnaire. *Maternal and Child Health Journal, 20*, 2179–2188. https://doi.org/10.1007/s10995-016-2071-4

Lee, E., Kim, H., Kim, H., Ha, E. H., & Chang, N. (2018). Association of maternal omega-6 fatty acid intake with infant birth outcomes: Korean Mothers and Children's Environmental Health (MOCEH). *Nutrition Journal, 17*, 1–9. https://doi.org/10.1186/s12937-018-0353-y

Lee, K. A., McEnany, G., & Zaffke, M. E. (2000). REM sleep and mood state in childbearing women: Sleepy or weepy? *Sleep, 23*(7), 877–885.

Littleton, H. L., Breitkopf, C. R., & Berenson, A. B. (2007). Correlates of anxiety symptoms during pregnancy and association with perinatal outcomes: A meta-analysis. *American Journal of Obstetrics and Gynecology, 196*(5), 424–432. https://doi.org/10.1016/j.ajog.2007.03.042

Liu, J., Laditka, J. N., Mayer-Davis, E. J., & Pate, R. R. (2008). Does physical activity during pregnancy reduce the risk of gestational diabetes among previously inactive women? *Birth, 35*(3), 188–195. https://doi.org/10.1111/j.1523-536X.2008.00239.x

Lobel, M. (1996). *The prenatal health behavior scale—revised*. State University of New York at Stony Brook.

Lobel, M., Cannella, D. L., Graham, J. E., DeVincent, C., Schneider, J., & Meyer, B. A. (2008). Pregnancy-specific stress, prenatal health behaviors, and birth outcomes. *Health Psychology, 27*(5), 604–615. https://doi.org/10.1037/a0013242

Lu, Q., Lu, M. C., & Schetter, C. D. (2005). Learning from success and failure in psychosocial intervention: An evaluation of low birth weight prevention trials. *Journal of Health Psychology, 10*(2), 185–195. https://doi.org/10.1177/1359105305049763

Malek, L., Umberger, W., Makrides, M., & Zhou, S. J. (2016). Adherence to the Australian dietary guidelines during pregnancy: Evidence from a national study. *Public Health Nutrition, 19*(7), 1155–1163.

Micheli, K., Komninos, I., Bagkeris, E., Roumeliotaki, T., Koutis, A., Kogevinas, M., & Chatzi, L. (2011). Sleep patterns in late pregnancy and risk of preterm birth and fetal growth restriction. *Epidemiology, 22*(5), 738–744.

Middleton, P., Gomersall, J. C., Gould, J. F., Shepherd, E., Olsen, S. F., & Makrides, M. (2018). Omega-3 fatty acid addition during pregnancy. *Cochrane Database of Systematic Reviews*. https://doi.org/10.1002/14651858.CD003402.pub3

Mitchell, A. M., Kowalsky, J. M, Epel, E. S., Lin, J., & Christian, L. M. (2018). Childhood adversity, social support, and telomere length among perinatal women. *Psychoneuroendocrinology*, *87*, 43–52.

Mollayeva, T., Thurairajah, P., Burton, K., Mollayeva, S., Shapiro, C. M., & Colantonio, A. (2016). The Pittsburgh sleep quality index as a screening tool for sleep dysfunction in clinical and non-clinical samples: A systematic review and meta-analysis. *Sleep Medicine Reviews, 25*, 52–73. https://doi.org/10.1016/j.smrv.2015.01.009

National Institute on Minority Health and Health Disparities (2017). NIMHD research framework. Retrieved from https://www.nimhd.

nih.gov/about/overview/research-framework.html. Accessed 19 Aug 2021.
Okun, M. L., & Coussons-Read, M. E. (2007). Sleep disruption during pregnancy: How does it influence serum cytokines? *Journal of Reproductive Immunology, 73*(2), 158–165. https://doi.org/10.1016/j.jri.2006.06.006
Okun, M. L., Schetter, C. D., & Glynn, L. M. (2011). Poor sleep quality is associated with preterm birth. *Sleep, 34*(11), 1493–1498. https://doi.org/10.5665/sleep.1384
Omidvar, S., Faramarzi, M., Hajian-Tilak, K., & Amiri, F. N. (2018). Associations of psychosocial factors with pregnancy healthy life styles. *PLoS ONE, 13*(5), e0191723. https://doi.org/10.1371/journal.pone.0197389
Osborne, J. W., & Overbay, A. (2004). The power of outliers (and why researchers should always check for them). *Practical Assessment, Research & Evaluation, 9*(6), 1–12. https://doi.org/10.7275/qf69-7k43
Park, E.-W., Tudiver, F., Schultz, J. K., & Campbell, T. (2004). Does enhancing partner support and interaction improve smoking cessation? A meta-analysis. *The Annals of Family Medicine, 2*(2), 170–174. https://doi.org/10.1370/afm.64
Pereira, M. A., Rifas-Shiman, S. L., Kleinman, K. P., Rich-Edwards, J. W., Peterson, K. E., & Gillman, M. W. (2007). Predictors of change in physical activity during and after pregnancy: Project Viva. *American Journal of Preventive Medicine, 32*(4), 312–319. https://doi.org/10.1016/j.amepre.2006.12.017
Pottala, J. V., Espeland, M. A., Polreis, J., Robinson, J., & Harris, W. S. (2012). Correcting the effects of −20 °C storage and aliquot size on erythrocyte fatty acid content in the Women's Health Initiative. *Lipids, 47*(9), 835–846. https://doi.org/10.1007/s11745-012-3693-y
Prezza, M., & Giuseppina Pacilli, M. (2002). Perceived social support from significant others, family and friends and several sociodemographic characteristics. *Journal of Community & Applied Social Psychology, 12*(6), 422–429. https://doi.org/10.1002/casp.696
Prochaska, J. J., Spring, B., & Nigg, C. R. (2008). Multiple health behavior change research: An introduction and overview. *Preventive Medicine, 46*(3), 181–188. https://doi.org/10.1016/j.ypmed.2008.02.001
Qawasmi, A., Landeros-Weisenberger, A., & Bloch, M. H. (2013). Meta-analysis of LCPUFA supplementation of infant formula and visual acuity. *Pediatrics, 131*(1), e262–e272. https://doi.org/10.1542/peds.2012-0517
Rodriguez, A., Bohlin, G., & Lindmark, G. (1999). A longitudinal study of perceived health during pregnancy: Antecedents and outcomes. *Journal of Health Psychology, 4*(2), 129–147. https://doi.org/10.1177/135910539900400209
Saini, R. K., & Keum, Y. S. (2018). Omega-3 and omega-6 polyunsaturated fatty acids: Dietary sources, metabolism, and significance—A review. *Life Sciences, 203*, 255–267. https://doi.org/10.1016/j.lfs.2018.04.049
Schytt, E., & Hildingsson, I. (2011). Physical and emotional self-rated health among Swedish women and men during pregnancy and the first year of parenthood. *Sexual & Reproductive Healthcare, 2*(2), 57–64. https://doi.org/10.1016/j.srhc.2010.12.003
Shapiro, G. D., Fraser, W. D., Frasch, M. G., & Séguin, J. R. (2013). Psychosocial stress in pregnancy and preterm birth: Associations and mechanisms. *Journal of Perinatal Medicine, 41*(6), 631–645. https://doi.org/10.1515/jpm-2012-0295
Skouteris, H., Wertheim, E. H., Germano, C., Paxton, S. J., & Milgrom, J. (2009). Assessing sleep during pregnancy: A study across two time points examining the Pittsburgh Sleep Quality Index and associations with depressive symptoms. *Women's Health Issues, 19*(1), 45–51. https://doi.org/10.1016/j.whi.2008.10.004
Solar, O., Irwin, A. (2010). A conceptual framework for action on the social determinants of health. Social Determinants of Health Discussion Paper 2 (Policy and Practice). Geneva, World Health Organization.
Sowers, M. F., Zheng, H., Kravitz, H. M., Matthews, K., Bromberger, J. T., Gold, E. B., Owens, J., Consens, F., & Hall, M. (2008). Sex steroid hormone profiles are related to sleep measures from polysomnography and the Pittsburgh Sleep Quality Index. *Sleep, 31*(10), 1339–1349. https://doi.org/10.5665/sleep/31.10.1339
Stepanikova, I., Kukla, L., & Svancara, J. (2016). Predictive value of self-rated health in pregnancy for childbirth complications, adverse birth outcomes, and maternal health. *International Journal of Gynecology & Obstetrics, 135*(1), 56–60. https://doi.org/10.1016/j.ijgo.2016.03.029
Stotland, N. E., Cheng, Y. W., Hopkins, L. M., & Caughey, A. B. (2006). Gestational weight gain and adverse neonatal outcome among term infants. *Obstetrics & Gynecology, 108*, 635–643. https://doi.org/10.1097/01.AOG.0000228960.16678.bd
Sun, Q., Ma, J., Campos, H., Hankinson, S. E., & Hu, F. B. (2007). Comparison between plasma and erythrocyte fatty acid content as biomarkers of fatty acid intake in US women. *The American Journal of Clinical Nutrition, 86*(1), 74–81. https://doi.org/10.1093/ajcn/86.1.74
Thornton, P. L., Kieffer, E. C., Salabarría-Peña, Y., Odoms-Young, A., Willis, S. K., Kim, H., & Salinas, M. A. (2006). Weight, diet, and physical activity-related beliefs and practices among pregnant and postpartum Latino women: The role of social support. *Maternal and Child Health Journal, 10*, 95–104. https://doi.org/10.1007/s10995-005-0025-3
Tomfohr, L., Buliga, E., Letourneau, N., Campbell, T., & Giesbrecht, G. (2015). Trajectories of sleep quality and associations with mood during the perinatal period. *Sleep, 38*(8), 1237–1245. https://doi.org/10.5665/sleep.4900
Tucker, C. M., Roncoroni, J., & Buki, L. P. (2019). Counseling psychologists and behavioral health: Promoting mental and physical health outcomes. *The Counseling Psychologist, 47*(7), 970–998. https://doi.org/10.1177/0011000019896784
Uchino, B. N. (2009). Understanding the links between social support and physical health: A life-span perspective with emphasis on the separability of perceived and received support. *Perspectives on Psychological Science, 4*(3), 236–255. https://doi.org/10.1111/j.1745-6924.2009.01122.x
Uchino, B. N. (2012). Understanding the links between social ties and health: On building stronger bridges with relationship science. *Journal of Social and Personal Relationships, 30*(2), 155–162. https://doi.org/10.1177/0265407512458659
Uchino, B. N., Kent de Grey, R. G., & Cronan, S. (2016). The quality of social networks predicts age-related changes in cardiovascular reactivity to stress. *Psychology and Aging, 31*(4), 321–326. https://doi.org/10.1037/pag0000092
Viau, P. A., Padula, C. A., & Eddy, B. (2002). An exploration of health concerns & health-promotion behaviors in pregnant women over age 35. *MCN: the American Journal of Maternal/child Nursing, 27*(6), 328–334.
Ware, J., & Sherbourne, C. (1992). The MOS 36-item short-form health survey (SF-36): I. Conceptual framework and item selection. *Medical Care, 30*(6), 473–483.
Yim, I. S., Tanner Stapleton, L. R., Guardino, C. M., Hahn-Holbrook, J., & Dunkel Schetter, C. (2015). Biological and psychosocial predictors of postpartum depression: Systematic review and call for integration. *Annual Review of Clinical Psychology, 11*, 99–137. https://doi.org/10.1146/annurev-clinpsy-101414-020426
Zimet, G. D., Dahlem, N. W., Zimet, S. G., & Farley, G. K. (1988). The multidimensional scale of perceived social support. *Journal of Personality Assessment, 52*(1), 30–41. https://doi.org/10.1207/s15327752jpa5201_2

Zimet, G. D., Powell, S. S., Farley, G. K., Werkman, S., & Berkoff, K. A. (1990). Psychometric characteristics of the multidimensional scale of perceived social support. *Journal of Personality Assessment, 55*(3–4), 610–617. https://doi.org/10.1080/00223891.1990.9674095

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