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Psychosocial Stress during First Pregnancy Predicts Infant Health Outcomes in the First Postnatal Year

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Abstract

Objective—To evaluate the impact of psychosocial stress during pregnancy on infant health outcomes in the first postnatal year.

Methods—A sample of 3000 women completed a stress inventory (the Psychosocial Hassles Scale) during their third trimester before first childbirth. Infant health outcomes were measured via maternal report at 1, 6 and 12 months postpartum. Poisson regression was used to model the effect of maternal stress during pregnancy on infant health outcomes in the first year, controlling for age, race/ethnicity, education, insurance coverage, marital status, and cigarette smoking during pregnancy.

Results—Women who were younger, minority, unmarried, publicly insured and without a college degree were more likely to report high levels of prenatal stress. High prenatal stress was a significant predictor of maternal reporting of gastrointestinal illness ($p<0.0001$), respiratory illness ($p=0.025$), and total illness in the first year ($p< 0.0001$). High prenatal stress was also a significant predictor of urgent care visits ($p< 0.0001$) and emergency department visits ($p= 0.001$). It was not a significant predictor of hospitalizations ($p= 0.36$).

Conclusions—Maternal prenatal stress is associated with increased maternal reporting of infant illness, as well as increased frequency of both urgent care visits and emergency department visits.

Keywords

prenatal stress; infant health; urgent care; health care utilization; pregnancy

Introduction

A growing body of literature indicates that high levels of prenatal stress are associated with adverse outcomes for the developing fetus [1–4]. The bulk of current research on prenatal stress focuses on associated gestational complications [5–11] and long-term neurobehavioral effects [12–23]. However, current knowledge concerning the child health effects of prenatal stress is limited to a small subset of conditions, including childhood asthma [24–26], eczema [27], obesity [28, 29], childhood cancers [30, 31], and birth defects [32, 33]. Although often overlooked, minor infant illnesses that are frequent and prevalent, like coughs and colds,

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have an enormous impact on families, and result in 22 million missed days of school annually and 2 million lost caregiver workdays in the US [34].

Despite the size of the problem, few studies have investigated the impact of prenatal stress on minor but common infant illness. A recent study demonstrated that children exposed to prenatal stress experience an increase in hospitalizations due to “less severe acute infectious diseases,” including pneumonia, upper respiratory tract infections, gastroenteritis, cystitis, bronchitis, conjunctivitis, or influenza. However, illnesses too minor to require hospitalization were excluded [35]. A study of Dutch pregnancies found that child respiratory illnesses, general illnesses, skin disorders, and antibiotic use in the first year of life were associated with maternal prenatal stress [36]. To our knowledge, none of the previous studies on the child health effects of stress during pregnancy measured health care utilization.

The goal of this study was to delineate the relationship between prenatal stress and minor infant illness in a large, prospective longitudinal study of a diverse sample of first-time mothers. We also aimed to determine whether prenatal stress was associated with increased frequency of urgent care visits, emergency department (ED) visits, and hospitalizations. We hypothesized that the children of women reporting high levels of stress during pregnancy would experience more frequent bouts of minor illness and increased health care utilization.

Methods

Study Design

Data originated from the First Baby Study (FBS), a longitudinal prospective cohort study that surveyed women having their first, singleton baby about experiences during pregnancy, delivery, and the postpartum period. The purpose of the FBS was to investigate the association between mode of first delivery and subsequent childbearing. Study procedures were approved by the Pennsylvania State College of Medicine Institutional Review Board (IRB) and the IRBs of participating hospitals across Pennsylvania. Informed consent was obtained in writing from participants prior to enrollment, after they reached at least 24 weeks gestation. This research was conducted in accord with prevailing ethical principles.

Recruitment

Participants were recruited via (1) flyers, posters, and brochures at hospitals, obstetrician’s offices, low-income clinics, ultrasound centers, and community health centers; (2) press releases and advertisements sent to local publications; (3) hospital intranet postings and webpage announcements; (4) mailings sent by a Medicaid insurer and a marketing company; and (5) brochure distribution at childbirth education classes and hospital tours at participating institutions. Participants delivered between January 2009 and April 2011.

Among the participants who completed the baseline interview, 74 did not complete the 1-month interview, some because of fetal demise, but most because of a decision not to continue participation. Those who dropped out of the study after the first interview were compared to those who did not using t-tests for continuous variables and chi-square tests for categorical variables. Those who dropped out of the study were different from those who

completed the 1 month interview in that they were younger, less likely to be covered by private insurance, and more likely to live in an urban area. They were not significantly different in race/ethnicity [37]. These drop-outs were replaced until targeted enrollment of 3,000 was met, with a final total of 3,006 enrolled participants. There were 2,910 women who completed the 6-month interview, and 2,802 who completed the 12-month interview.

Inclusion/Exclusion Criteria

Women were eligible to participate if they were between the ages of 18 and 35 at the baseline interview, residents of Pennsylvania, primiparous, currently pregnant with a singleton pregnancy, able to speak and read English or Spanish, planning to deliver in a Pennsylvania hospital, and willing to provide written informed consent [38]. Women under the care of a midwife were included. Exclusion criteria included: plans to deliver at home or in a birthing center not affiliated with a hospital, plans for the infant to be adopted, plans to have a tubal ligation while hospitalized for delivery, history of a previous stillbirth at more than 20 weeks gestation, not having a telephone, or being unable to commit to the study period of 3 years. Women who planned to have a tubal ligation while hospitalized for delivery were excluded because the primary purpose of the First Baby Study was to investigate childbearing subsequent to first childbirth as a function of mode of first delivery (cesarean or vaginal).

Interviews

The prenatal and postpartum interviews (1, 6, and 12 months) were conducted by telephone by trained, professional interviewers employed by the Penn State Harrisburg Center for Survey Research. Baseline (prenatal) interviews were conducted prior to the beginning of labor, between 30 and 42 weeks of gestation, at a median of 35 weeks gestation. The baseline interview assessed pregnancy complications, psychosocial factors, and demographics. The 1-month, 6-month, and 12-month postpartum telephone interviews focused on delivery experience, post-discharge complications, and the health of the mother and baby. The covariates of maternal age, race/ethnicity, education, marital status and smoking during pregnancy were obtained by self-report in the baseline interview. Insurance coverage was obtained from the hospital discharge data. Participants who smoked “every day” or “some days” during pregnancy were categorized as “smokers.” Stress during pregnancy was measured as part of the baseline survey using a modified version of the 12-item Psychosocial Hassles Scale (Appendix 1) [39]. We chose to use this specific instrument because it was one of only a handful of scales designed to measure stress during pregnancy at the time that we began pilot testing for this study (2006), it was brief, and it was highly recommended by other investigators. This instrument was originally developed for use among low-income, minority women living in an urban area. Pilot-testing in Central Pennsylvania indicated that the items “Sexual, emotional or physical abuse” and “Problems with alcohol or drugs” did not work well in our study population of primarily White, suburban and rural women. Therefore, these two items were changed to 1.) “Fights with partner” and 2.) “Fights with other family members.” Response options were “No stress,” “Some stress,” Moderate stress,” and “Severe stress.” The two new items exhibited good corrected item-total correlations of 0.44 and 0.42, and the overall Cronbach’s alpha was 0.76, which was an improvement in the Cronbach’s Alpha of 0.69 that we had obtained in

our pilot study with the original items. Total scores ranged from 12 (no stress) to 48 (severe stress) and responses were grouped into tertiles: 12–16 (low stress), 17 to 20 (medium stress), and 21 and above (high stress). Participants who indicated “don’t know” or “refuse to answer” on one or more items of the Psychosocial Hassles Scale were excluded from this study (n =6).

Incidence of maternal report of minor infant illness was measured using an 8-item questionnaire that differed slightly at each time point (1-month, 6-months, and 12-months) to reflect illnesses most prevalent in the age group (Appendix 2). This instrument was developed by a pediatrician to reflect common reasons for doctor visits in the first year. Mothers were asked to report incidence of these illnesses in the four weeks prior to the survey, thus data collected reflected illnesses in the first, fifth, and eleventh months of life. There was no additional probing beyond the questions seen in Appendix 2. Illnesses were sorted into three categories: “Respiratory illness,” which included cough or cold, respiratory infections, and asthma; “Gastrointestinal illness,” which included constipation, diarrhea, food allergy, colic, and milk intolerance; and “Other illness,” which included fever >100.4°F for >24h, ear infection, poor weight gain, thrush, diaper rash, eczema, and jaundice. The total number of gastrointestinal illnesses in the first year was summed to create a gastrointestinal composite, which could range from zero to eight. The same was done to form a respiratory illness composite, which could range from zero to seven. At least one response of “Yes” to any of the illnesses listed in the “Minor Infant Illness Questionnaire” (Appendix 2) at any of the three time points (in the first month, the 5^{th} month or the 11^{th} month) qualified an infant as having at least one bout of minor illness. A “total illness” composite was created, which summed all of these minor illnesses in the first year and could range from zero to a maximum possible of twenty-five. Participants missing data from an infant illness questionnaire at a time point were excluded from relevant composite scores (n=295 for the GI composite score, n=262 for the respiratory illness score, and n=339 for the total illness scores). An “other illness” composite was not created due to the limited biological relationship of these variables, and because these were included in the “total illness” composite.

Infant urgent care visits, emergency department visits, and hospitalizations were measured via maternal report at each time point. Mothers were asked, “Since the last interview has your baby had to go the emergency room?” If the mother said “Yes” they were then asked how many times their baby had to go to the emergency room, the reasons for each visit and the services received at each visit. Mothers were then asked, “Has your baby been admitted to the hospital?” If they answered “yes” they were then asked to report how many times their baby had been admitted to the hospital, how many total days the baby had been in the hospital and the medical problem for each hospitalization. Mothers were also asked, “Since your last interview, how many doctor office or urgent care visits, including any routine postpartum check-ups or immunization visits has your baby had?” For each visit they were asked to specify the reason for the visit and whether it was for routine or urgent care. The classification of visits as urgent versus routine were reviewed by the study investigators. In rare cases the reasons for the office visit did not match the mother’s classification as routine or urgent. In those cases, the visits were reclassified accordingly. For example, if the mother reported a scheduled visit for immunization as an urgent care visit it was reclassified as a

routine visit. In addition, if a visit for a reason such as “The baby was running a high temperature” was classified as routine, that visit was reclassified as urgent. The 1 month survey inquired about health care utilization in the first month after childbirth; the six month survey about 1–6 months; and the 12 month survey about 6–12 months. Number of urgent care visits reported during the 1 month, 6 month, and 12 month surveys were summed to create a score of total number of urgent care visits in the first year. Similar scores were also calculated for ED visits and hospitalizations.

To determine the poverty category of each participant we used the US Census Bureau thresholds for poverty and categories of income related to poverty for 2009 to 2011, depending upon the year of the participant baseline interview. Participants with household incomes ≥ 200% above the poverty threshold were categorized as “not poverty”, those at 100% to 200% were “near poverty”, and those < 100% were classified as “poverty”, according to the US Census Bureau algorithm.

Statistical Analysis

Data analysis was completed using SPSS (ver. 22). The primary relationships investigated were (1) the relationship between stress score and minor infant illness and (2) the relationship between stress score and health care utilization measures. Bivariate associations between stress scores and each minor infant illness, and between stress scores and urgent care visits, emergency department visits, and hospitalizations were performed for each time point using chi-square tests of independence. Poisson regression models were then used to estimate the association between prenatal stress and the six healthcare outcome composite scores for the first postnatal year: respiratory illness, gastrointestinal illness, total illness, urgent care visits, ED visits, and hospitalizations, controlling for the covariates of maternal age (18 to 24 versus 25 and older), race (Black or Hispanic versus White non-Hispanic or other), education (less than a college degree versus a college degree or higher), insurance coverage (public versus private), marital status (non-married versus married), and cigarette smoking during pregnancy (smoking during pregnancy versus not smoking). We used Poisson regression models because the dependent variables were count variables and were not normally distributed.

Results

Demographic and psychosocial characteristics of the 3,000 women in the cohort are presented in Table 1. The mean age was 27.2 ±4.4, and the majority self-reported as White non-Hispanic (83.3%), married (70.6%), and college-educated (56.7%). The majority of the newborns were full term (60.3%), in the normal range for birth weight (2500–4000 grams), (86.3%), and with Apgar scores of 9–10 (75.8%). The lowest score on the stress scale was 12 and the highest was 43. The mean score was 18.6 (SD = 4.5) and the median was 18.0.

As seen in Table 2, women in the high-stress tertile were significantly more likely to be in the youngest age group (18–24), Black non-Hispanic, publicly insured, in poverty and to smoke during the pregnancy. They were less likely to have a college degree or to be married. Prenatal stress was not associated with gestational age in this study (Chi-square p = 0.839, as seen in Table 2), so gestational age was not included in the regression equations as a

confounder. In addition, gestational age at the time of the prenatal interview was not associated with stress, (one-way ANOVA (p = 0.309)), as seen in Table 2. The Pearson correlation between gestational age at first interview and the stress score was near zero (.03).

Table 3 shows the associations between prenatal stress and the infant health outcomes. High prenatal stress was significantly associated with maternal report of cough or cold, constipation, diarrhea, food allergy, colic, and milk intolerance. Prenatal stress was particularly strongly associated with emergency department visits.

Table 4 shows the descriptive statistics for the overall child illness and health care utilization measures we developed. While only 8.0% of the mothers reported no illness events across the first year (at least during the first, 5^{th} and 11^{th} months), most of the children were not hospitalized at any time (93.2%), and the majority were not brought to the emergency department (74.3%) during the first postnatal year.

In the Poisson regression models (Table 5), high prenatal stress was significantly predictive of respiratory illnesses (p=0.025), gastrointestinal illnesses (p< 0.0001), and total illnesses in the first year (p< 0.0001). Cigarette smoking during pregnancy was also a significant risk factor for gastrointestinal illness (p< 0.0001), and total illness (p= 0.001) in the first year. Demographic factors including age, race, insurance type, and education were not significantly associated with any of the overall illness and health care utilization measures. Prenatal stress was predictive of urgent care visits in the first year (p< 0.0001), and ED visits in the first year (p= 0.001), but not hospitalizations (p=0.36). Black or Hispanic race, having fewer years of education, and public insurance all had significant negative association with urgent care office visits and a significant positive associations with ED visits, as seen in Table 5.

Discussion

This study demonstrates a significant association between psychosocial stress during pregnancy and maternal report of minor infant illness in the first postnatal year, as well as increased urgent-care visits and ED visits. This relationship persisted after controlling for relevant demographic and behavioral covariates. Our findings that prenatal stress were associated with maternal reported incidences of cough or cold and colic are in concordance with previous studies associating prenatal stress with colic, asthma, and general respiratory illnesses [36, 40]. Although we did not find asthma to be significantly associated with prenatal stress, our sample was likely too young to accurately assess incidence [24]. A positive relationship between prenatal stress and infant gastrointestinal illness has not previously been demonstrated; however, in adults administered a psychosocial stress test, salivary cortisol increased and diarrhea and constipation symptoms worsened, suggesting a role for stress in gastrointestinal illness [41].

At least two mechanisms can help to explain a physiological relationship between stress and infant illness. The first is direct: chronic maternal stress during pregnancy acts on the hypothalamic-pituitary-adrenal axis, elevating corticotrophin-releasing hormone and cortisol. New studies have also implicated 11B-HSD2 enzyme and increased catecholamines

as potential mediators [42]. Although cortisol is necessary for fetal development, high concentrations compromise immunological, behavioral, and neural development [43]. The mechanisms by which glucocorticoids act on the fetus include binding to a glucocorticoid response element and altering local methylation, increasing expression of epigenetic regulator genes, and altering miRNA in the brain and hippocampus [44]. In animal models, the effects of elevated fetal cortisol include impaired cytokine secretion, reduced lymphocytic activity, and reduced white blood cell counts that continue beyond infancy [35]. Several studies have shown that these developmental effects may be multigenerational [45, 46]. The second mechanism is indirect: stress during pregnancy is positively associated with caffeine consumption, poor sleep habits, and smoking, and is inversely associated with exercise, vitamin use, and healthy diet [47, 48]. Each of these behaviors may then have a physiological effect on the fetus.

Another possible mechanism is psychological: mothers who experience high levels of prenatal stress may be hyper-vigilant for illness in the infant, both reporting more illnesses and requiring a lower threshold to bring their child for an urgent care or ED visit. This effect has been documented in mothers who experience high post-natal stress: in studies of toddlers and young children, mothers' estimates of their current or recent stress levels were predictive of the number of visits their child had with their primary care doctor [49, 50]. Other studies have refuted this claim, arguing that mothers are able to appropriately separate decision making about health care from their stress level [51]. The most likely mechanism is multimodal, incorporating both physiological and psychological effects of stress.

Cigarette smoking during pregnancy was also a significant predictor of gastrointestinal illness, total illness, and ED visits. Smoking is the leading causes of infant morbidity and mortality in the US [52, 53], and has previously been linked with developmental defects [54], asthma and allergies [55], infantile colic [56], as well as with hospitalization and mortality due to infection [57]. A number of mechanisms have been postulated for the detrimental effects of smoking during pregnancy, including epigenetic mechanisms like altered placental DNA methylation [58] and differential miRNA expression [59].

Although previous studies have reported associations between stress during pregnancy and preterm birth [60], in this study stress during pregnancy was not associated with preterm birth or gestational age. The most likely reason that we did not see this association was that the prenatal interviews took place in the third trimester, at 35 weeks gestation on average. There is some evidence that stress experienced in the 5^{th} and 6^{th} month of pregnancy (as opposed to before or after) is most strongly associated with preterm delivery [5]. Our study participants were well past that point when they were asked about their stress experiences, and only 4.0% delivered preterm.

Despite the strengths of our study design, there are also limitations that merit comment. First, participants in this study tended to be older, more educated, and more likely to be White than the overall population of women having their first child in Pennsylvania [37], potentially limiting the external validity of our results. In addition, since the women who dropped out of the study were more likely to be younger, in poverty and unmarried, this study has a higher level of selection bias than studies with more representative samples.

Additionally, the maternal-report measures of minor infant illnesses asked only about the month prior to each interview and therefore do not provide a complete picture of the occurrence of these outcomes. While our measures of health care utilization at 6 and 12 months postpartum refer to the entire time period since the previous interview, these items are self-report as well, and like the measures of infant illnesses, are subject to recall bias. It would have been preferable to measure these outcomes via review of office records, had we been able to do so.

In conclusion, in this study we found that prenatal stress was associated with maternal reporting of minor infant illness and with increased healthcare utilization for the child in the first postnatal year. These results extend current knowledge of the adverse effects of stress during pregnancy and provide further support for the value of efforts to find effective methods to reduce stress during pregnancy. A recent review of stress reduction strategies during pregnancy [61] reported that group prenatal care programs, such as *Centering Pregnancy* [62], provided education and emotional support throughout pregnancy and were the most effective interventions for decreasing preterm birth and low birth weight. We suggest that health care providers make an effort to discuss stress during pregnancy with their patients, and to provide advice for stress relief interventions as a way to potentially improve pregnancy experience, neonatal health, and to limit unnecessary health care expenditure.

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Appendix 1: Psychosocial Hassles Scale

Now I am going to ask you about some things that might have occurred during this pregnancy that might have made you feel stressed or upset. Please tell me how much of a hassle the following things were for you - have they caused no stress, some stress, moderate stress, or severe stress for you during your pregnancy?

		No stress	Some stress	Moderate stress	Severe stress	Don't know	Refuse to respond
a	Worries about food, shelter, health care, and transportation	1	2	3	4	8	9
b	Money worries like paying bills	1	2	3	4	8	9
c	Problems related to family	1	2	3	4	8	9
d	Having to move, either recently or in the future	1	2	3	4	8	9
e	Recent loss of a loved one	1	2	3	4	8	9
f	The pregnancy itself	1	2	3	4	8	9
g	Fights with partner	1	2	3	4	8	9
h	Fights with other family members	1	2	3	4	8	9
i	Work or job problems	1	2	3	4	8	9
j	Problems with your friends	1	2	3	4	8	9
k	Feeling generally overloaded	1	2	3	4	8	9
l	Crime or safety in your neighborhood	1	2	3	4	8	9

Appendix 2: Minor Infant Illness Questionnaires

1-month: Next is a list of illnesses babies may have. Please tell me if your baby has had any of the following problems during the past 4 weeks.

		Yes	No	Don't Know	Refuse to respond
a	Cough or cold	1	2	8	9
b	Respiratory infection (respiratory flu, bronchitis, respiratory distress syndrome)	1	2	8	9
c	Jaundice requiring light therapy or biliblanket	1	2	8	9
d	Fever of 100.4 F or more 24 hours or more	1	2	8	9
e	Colic: crying/fussiness three or more hours a day	1	2	8	9
f	Thrush (a fungal infection of the mouth)	1	2	8	9
g	Poor weight gain	1	2	8	9
h	Breast milk or formula intolerance	1	2	8	9
i	Food Allergy	1	2	8	9

6-month: Next is a list of illnesses babies may have. Please tell me if your baby has had any of the following problems during the past 4 weeks

		Yes	No	Don't Know	Refuse to respond
a	Cough or cold	1	2	8	9
b	Respiratory infection (respiratory flu, asthma, bronchiolitis, RSV)	1	2	8	9
c	Ear infection	1	2	8	9
d	Fever of 100.4 F or more 24 hours or more	1	2	8	9
e	Constipation	1	2	8	9
f	Diarrhea	1	2	8	9
g	Diaper rash	1	2	8	9
h	Allergic reaction to a new food	1	2	8	9

12-month: Next is a list of illnesses babies may have. Please tell me if your baby has had any of the following problems during the past 4 weeks.

		Yes	No	Don't Know	Refuse to respond
a	Cough or cold	1	2	8	9
b	Respiratory infection (respiratory flu, asthma, bronchiolitis, RSV)	1	2	8	9
c	Asthma	1	2	8	9
d	Eczema (a skin rash caused by an allergic reaction)	1	2	8	9
e	Ear infection	1	2	8	9
f	Fever of 100.4 F or more 24 hours or more	1	2	8	9
g	Constipation	1	2	8	9
h	Diarrhea	1	2	8	9

		Yes	No	Don't Know	Refuse to respond
i	Allergic reaction to a new food	1	2	8	9

Table 1

Maternal and Newborn Characteristics of Study Participants

	All Women [n (%)]
Overall [n (%)]	3,000 (100)
Age (years)	
18–24	807 (26.9)
25–29	1,192 (39.7)
30–36	1,001 (33.4)
Race/Ethnicity	
Hispanic	165 (5.5)
White Non-Hispanic	2,499 (83.3)
Black Non-Hispanic	219 (7.3)
Other	116 (3.9)
Education	
High school degree or less	497 (16.6)
Some college/technical	803 (26.8)
College degree or higher	1,700 (56.7)
Insurance	
Public	682 (22.8)
Private	2,307 (77.2)
Marital Status	
Married	2,117 (70.6)
Living with partner	542 (18.1)
Does not live with partner	185 (6.2)
Unattached	155 (5.2)
Poverty Status	
Poverty	253 (8.5)
Near poverty	337 (11.3)
Not in poverty	2,402 (80.3)
Smoking during pregnancy	
Yes	312 (10.4)
No	2,688 (89.6)
Gestational age at prenatal interview in weeks (M, SD)	35.2 (1.6)
Gestational age at birth (weeks)	
Preterm (34 2/7–36 6/7)	120 (4.0)
Early term (37 0/7–38 6/7)	575 (19.1)
Full term (30 0/7–40 6/7)	1814 (60.3)
Late term (41 0/7–41 6/7)	463 (15.4)
Post term (42 0/7–43 2/7)	34 (1.1)
Birthweight (grams)	
< 2500 (underweight)	91 (3.1)
2500–4000 (normal)	2569 (86.3)

	All Women [n (%)]
> 4000 (overweight)	316 (10.6)
Gender	
Male	1515 (50.5)
Female	1485 (49.5)
5 Minute Apgar Score	
1–7	141 (4.7)
8	579 (19.5)
9–10	2255 (75.8)

Table 2

Maternal socio-demographic characteristics by stress (Psychosocial Hassles Scale)

	Low Stress (%)	Medium Stress (%)	High Stress (%)	*p* value[a]
Overall [n (%)]	1,066 (35.5)	1,123 (37.3)	811 (27.0)	
Age (years)				<0.0001
18–24	28.9	31.1	40.0	
25–29	36.9	38.1	25.0	
30–36	39.3	41.8	19.0	
Race/Ethnicity				<0.0001
Hispanic	31.5	34.5	33.9	
White Non-Hispanic	35.7	38.8	25.5	
Black Non-Hispanic	32.0	27.4	40.6	
Other	43.1	31.0	25.9	
Education				<0.0001
High school degree or less	33.0	30.8	36.2	
Some college/technical	30.1	35.5	34.4	
College degree or higher	38.8	40.3	20.9	
Insurance				<0.0001
Public	27.7	30.4	41.9	
Private	37.8	39.6	22.5	
Marital Status				<0.0001
Married	38.8	40.3	20.9	
Living with partner	28.2	34.3	37.5	
Does not live with partner	28.6	24.9	46.5	
Unattached	24.5	24.5	51.0	
Poverty Status				<0.0001
Poverty	30.0	30.4	39.5	
Near poverty	26.4	27.6	46.0	
Not in poverty	37.4	39.7	22.9	
Smoking during pregnancy				<0.0001
Yes	20.8	31.7	47.4	
No	37.2	38.1	24.7	
Gestational age at prenatal interview in weeks (M, SD)	35.2 (1.5)	35.2 (1.6)	35.3 (1.6)	0.309
Gestational age at birth(weeks)				0.839
Preterm (34 2/7–36 6/7)	38.7	37.0	24.4	
Early term (37 0/7–38 6/7)	36.8	37.0	26.2	
Full term (30 0/7–40 6/7)	35.4	37.7	26.8	
Late term (41 0/7–41 6/7)	34.0	37.2	28.8	
Post term (42 0/7–43 2/7)	29.4	32.4	38.2	

Table 3

Chi square analyses for prenatal stress score by infant health outcomes

		Low Stress	Medium Stress	High Stress	
	N (%)	**%**	**%**	**%**	**P value[a]**
Respiratory Illness					
Cough or cold					
First month	368 (12.3)	9.4	11.2	17.5	<0.0001
Fifth month	1,420 (48.8)	45.8	49.2	52.4	0.018
Eleventh month	1,321 (47.3)	45.5	46.6	50.5	0.099
Respiratory Infection					
First month	21 (0.7)	0.5	0.9	0.7	0.49
Fifth month	152 (5.2)	4.3	5.7	5.9	0.20
Eleventh month	115 (4.1)	3.7	5.2	3.2	0.091
Asthma (6–12 months)	41 (1.5)	1.3	2.0	0.9	0.16
Gastrointestinal Illness					
Constipation					
Fifth month	581 (20.0)	18.6	18.6	2.9	0.007
Eleventh month	437 (15.6)	12.1	15.8	20.2	<0.0001
Diarrhea					
Fifth month	432 (14.9)	11.9	15.2	18.3	0.001
Eleventh month	688 (24.6)	19.7	24.9	30.8	<0.0001
Food allergy					
Fifth month	93 (3.2)	3.3	2.3	4.4	0.045
Eleventh month	109 (3.9)	3.4	3.5	5.1	0.14
Colic (first month)	348 (11.6)	8.0	11.6	16.4	<0.0001
Milk intolerance (first month)	213 (7.1)	5.6	6.0	10.8	<0.0001
Other Illness					
Fever >100.4 for 24h					
First month	10 (0.3)	0.6	0.3	0.1	0.23
Fifth month	120 (4.1)	3.7	4.7	4.1	0.42
Eleventh month	226 (8.1)	7.6	8.1	8.7	0.69

		Low Stress	Medium Stress	High Stress	
	N (%)	**%**	**%**	**%**	**P value[a]**
Ear infection					
Fifth month	244 (8.4)	7.9	9.0	8.2	0.62
Eleventh month	349 (12.4)	12.4	11.9	13.5	0.62
Poor weight gain (first month)	386 (12.9)	13.5	11.6	13.8	0.26
Thrush (first month)	153 (5.1)	4.7	5.3	5.4	0.73
Diaper rash (fifth month)	902 (31.0)	28.7	33.1	31.2	0.093
Eczema (eleventh month)	426 (15.3)	14.6	14.6	17.1	0.27
Jaundice (first month)	342 (11.4)	12.7	11.4	9.7	0.14
Urgent Care Visits					
≥1 from birth to 1 month	1,153 (38.4)	35.7	40.2	39.0	0.086
≥1 from 1– 6 months	1,458 (48.5)	45.2	50.0	51.2	0.020
≥1 from 6– 12 months	1,535 (51.5)	51.1	52.4	49.4	0.45
≥2 in first year	1,754 (58.3)	54.8	60.0	60.9	0.011
Emergency Department Visits					
≥1 from birth to 1 month	157 (5.2)	4.2	3.8	8.5	<0.0001
≥1 from 1– 6 months	358 (12.3)	10.6	10.5	17.2	<0.0001
≥1 from 6– 12 months	445 (15.9)	14.1	13.6	21.5	<0.0001
≥1 in first year	702 (25.4)	23.2	21.7	33.7	<0.0001
Hospitalizations					
≥1 from birth to 1 month	71 (2.4)	2.5	2.2	2.3	0.70
≥1 from 1– 6 months	85 (2.9)	2.5	3.2	3.1	0.59
≥1 from 6– 12 months	69 (2.5)	2.7	2.2	2.5	0.76
≥1 in first year	189 (6.9)	6.9	6.6	7.2	0.86

[a] *p* values were derived from the χ^2-test of independence

Table 4

Descriptive statistics for overall scores of infant illnesses and healthcare utilization in the first year

	Minimum	Maximum	Median	Mode	% with score of "0"	Mean (SD)
Respiratory Illness	0.00	5.00	1.00	1.00	29.2	1.15
Gastrointestinal Illness	0.00	6.00	1.00	0.00	42.6	0.97 (1.08)
Total Illnesses	0.00	13.00	3.00	2.00	8.0	3.17 (2.14)
Urgent Care Visits	0.00	14.00	2.00	0.00	20.9	2.53 (2.36)
Emergency Department Visits	0.00	12.00	0.00	0.00	74.3	0.44 (1.03)
Hospitalizations	0.00	12.00	0.00	0.00	93.2	.09 (.41)

Table 5

Poisson regressions estimating the effects of maternal stress during pregnancy and covariates on infant illnesses and healthcare utilization in the first year

	Respiratory Illness		Gastrointestinal Illness		Total Illnesses		Urgent Care Visits		Emergency Department Visits		Hospitalizations	
	Beta	**P value**	**Beta**	**P value**	**Beta**	**P value**	**Beta**	**P value**	**Beta**	**P value**	**Beta**	**P value**
High stress (vs low or medium stress)	0.090	0.025	0.29	<0.0001	0.14	<0.0001	0.17	<0.0001	0.19	0.001	−0.13	0.36
Under age 25 (vs. ≥25)	−0.006	0.27	0.002	0.77	−0.001	0.84	0.015	<0.0001	−0.028	0.001	−0.002	0.90
Black or Hispanic (vs white non-Hispanic or other)	0.045	0.47	−0.007	0.92	−0.005	0.91	−0.33	<0.0001	0.33	<0.0001	−0.25	0.21
<4y college degree (vs ≥ a college degree)	−0.064	0.16	0.054	0.28	−0.041	0.14	−0.15	<0.0001	0.35	<0.0001	0.034	0.84
Public insurance (vs private insurance)	0.015	0.81	0.056	0.37	0.010	0.78	−0.13	0.002	0.62	<0.0001	0.097	0.61
Non-married (vs married)	0.048	0.40	0.099	0.10	0.070	0.041	−0.047	0.22	0.31	<0.0001	0.60	0.001
Smoking during pregnancy (vs non-smoking)	0.075	0.25	0.27	<0.0001	0.12	0.001	0.038	0.40	0.19	0.009	−0.24	0.27