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Gestational weight gain in women with systemic lupus erythematosus

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Summary

Objective—To estimate the proportion of pregnant women with systemic lupus erythematosus (SLE) meeting Institute of Medicine (IOM) guidelines for gestational weight gain (GWG) and determine correlates of adherence to guidelines.

Methods—Singleton, live births in the Hopkins Lupus Pregnancy Cohort 1987-2015 were included. Pre-pregnancy weight was the weight recorded 12 months prior to pregnancy/first trimester. Final weight was the last weight recorded in the third trimester. Adherence to IOM guidelines (inadequate, adequate, or excessive) was based on pre-pregnancy body mass index (BMI). Fisher's exact test and ANOVA determined factors associated with not meeting guidelines. Stepwise selection estimated predictors of GWG.

Results—Of the 211 pregnancies, 34%, 24% and 42% had inadequate, adequate, and excessive GWG, respectively. In exploratory analyses, differences in IOM adherence were observed by pre-pregnancy BMI, race, elevated creatinine during pregnancy, and pre-pregnancy blood pressure. Odds of inadequate and excessive GWG increased 12% with each 1 kg/m^2 increase in pre-pregnancy BMI. Lower maternal education was associated with increased odds of inadequate and excessive GWG.

Conclusions—As in the general population, most women with SLE did not meet IOM guidelines. Our results identified predictors of GWG to aid in targeted interventions to improve guideline adherence in this population.

Keywords

systemic lupus erythematosus; pregnancy; gestational weight gain

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Conflicts of interest

The authors declare that there are no conflict of interest.

BACKGROUND

In 1990, the Institute of Medicine (IOM) published guidelines for ideal weight gain during pregnancy based on pre-pregnancy BMI. These guidelines were updated in 2009 due in part, to the concern of rising obesity rates in the population (1). Although the 2009 committee was not intended to develop gestational weight gain (GWG) guidelines for specific diseases or conditions, a noticeable gap in the literature was the availability of data on the weight gain patterns in patients with autoimmune diseases. Of particular interest was systemic lupus erythematosus (SLE), a disorder that largely affects women between the ages of 15 and 44 (2). It is not presently known if women with SLE are gaining the appropriate amount of weight and what factors may affect weight gain in these women.

Gestational weight gain is the amount of weight a mother gains throughout her pregnancy and is composed of maternal and fetal products of conception. The average weight gain attributable to fetal components is 4.8 kilograms, comprised of the fetus (3.3 kilograms), the placenta (0.7 kilograms) and amniotic fluid (0.8 kilograms). For maternal components, the average weight gained is 7 kilograms, largely due to increase in fat (4.0 kilograms), blood volume (1.2 kilograms) and extracellular fluid (1.2 kilograms) (3). The pattern of weight gain during pregnancy varies greatly among women. One study found the average weekly weight gain for the second and third trimesters was higher for underweight and normal weight women, compared to overweight and obese women. Additionally, in this study, all women except obese women had higher weekly rates of weight gain in the second trimester than in the third trimester (4).

The appropriate amount of weight gained during pregnancy has great implications for the infant: gaining too much weight during pregnancy has been shown to be associated with delivering large for gestational age or macrosomic (>4000 g) infants (5-21), while insufficient weight gain is associated with the delivery of a small for gestational age infant (6, 7, 10-16, 22). Gestational weight gain also has implications for preterm birth. There appears to be a U-shaped association of GWG with preterm birth, with modification by pre-pregnancy BMI (23-27). Among women who are underweight according to their pre-pregnancy BMI, insufficient GWG is associated with an increased risk of preterm birth, and this association weakens as pre-pregnancy BMI increases. Excessive GWG may be associated with preterm birth in women of all pre-pregnancy BMI categories (27, 28).

The vast majority of women in the general population do not meet the IOM guidelines for weight gain, with one study finding that 17% had inadequate, 31% had adequate weight gain, 53% of mothers had excessive weight gain (29). Women classified as overweight or obese were at increased risk of gaining more than the recommended amount of weight during pregnancy, compared to women with normal BMI. Unfortunately, the proportion of women who are exceeding the guidelines for GWG is increasing (29), which is why the IOM committee has called for a paradigm shift in how preconception and prenatal advice concerning weight gain is being delivered to women of childbearing ages. The objectives of this study were to estimate the proportion of women with SLE who meet the IOM guidelines for GWG and to determine correlates of adherence to IOM guidelines for GWG.

METHODS

Study population

The Hopkins Lupus Pregnancy Cohort is a subset of the Hopkins Lupus Cohort, which has prospectively followed patients with SLE since 1987, with data available through February 6, 2015 (n=515). Patients meeting the American College of Rheumatology (ACR) or Systemic Lupus International Collaborating Clinics (SLICC) criteria for SLE (30-32) were eligible for enrollment in the cohort following informed consent. Patients enrolled in the Hopkins Lupus Cohort and SLE patients seen in the Hopkins Obstetrics Clinics were automatically referred to the Hopkins Lupus Pregnancy Cohort. Outside of Johns Hopkins Hospital, local patients were referred by their local rheumatologists, the Maryland Lupus Foundation and self-referral (33). Pregnant women were seen every 4-6 weeks throughout their pregnancy at the Lupus Center in Baltimore, Maryland by a single rheumatologist (average 5.3 weeks). During each visit, a patient's weight was recorded, lupus disease activity was determined by the physician global assessment of disease activity (PGA), medications were updated and laboratory tests were conducted. Laboratory tests included complete blood count, complement levels, autoantibodies and urinalysis.

Gestational weight gain

The outcome of interest was the proportion of women with SLE who met the 2009 IOM guidelines for GWG based on pre-pregnancy BMI. Pre-pregnancy weight was defined as the most recent weight recorded at a visit within 12 months prior to pregnancy (average weeks prior to pregnancy: 8.4 weeks, SD: 1.9) or, if not available in the first trimester (n=64, average gestational age: 8.4 weeks, SD: 3.2). The final pregnancy weight was the weight recorded closest to birth in the third trimester (average gestational age: 34.8 weeks, SD: 2.9). Observed weight gain was calculated as the difference in the first and final weight measurement. The estimated total weight gain was calculated to account for variations in the timing of the first and final weight: (observed weight gain / weeks of gestation between weight measurements) × 40 weeks.

The estimated total weight gain was classified according to IOM guidelines based on a woman's pre-pregnancy BMI: underweight (<18.5 kg/m^2), normal weight (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2), obese (≥30 kg/m^2). The guidelines recommend the following total weight gain during pregnancy (1):

- underweight: 12.5-18 kg
- normal weight: 11.5-16 kg
- overweight: 7-11.5 kg
- obese 5-9 kg.

Total weight gain below the recommendations is considered inadequate weight gain, and total weight above the recommendations is considered excessive weight gain.

Covariates

Population characteristics of interest included self-reported race (black vs. non-black), education, age at conception and duration of SLE. Infant birth date (categorized as prior to January 1999 or between January 1999-February 2015) was considered a variable of interest due to changes in SLE prescribing patterns and general population shifts in BMI over time. Information on medication SLE treatment used during pregnancy included: anti-malarial, immunosuppressants, prednisone, and prednisone ≥15 mg/day. Clinical characteristics and biomarkers of SLE recorded as ever occurring during pregnancy were: renal involvement (renal Lupus Activity Index >1), elevated serum creatinine (>1 mg/dl), high Physician Global Assessment (PGA ≥2), low complement (C3 and C4), and anti-dsDNA (ever positive). Maternal cumulative organ system damage at conception was measured by the SLICC/American College of Rheumatology Index (SDI), with a score of ≥1 representing the presence of any organ system damage. Pre-pregnancy blood pressure on the study visit closest to conception in the one-year prior to pregnancy or 1st trimester was classified according to American Heart Association (AHA) criteria for cardiovascular health: poor/intermediate blood pressure: systolic ≥120 or diastolic ≥80 mm Hg or treated to goal; ideal health: <120 and <80 mm Hg without treatment (34). Pre-pregnancy total cholesterol on the study visit closest to conception in the one-year prior to pregnancy or 1st trimester was classified according to AHA criteria for cardiovascular health: poor/intermediate total cholesterol: ≥200 mg/dL or treated to goal; ideal health: <200 mg/dL without treatment (34).

Pregnancy outcomes of interest included gestational age at birth and birth weight for gestational age z-score. Gestational age at birth was based on maternally reported last menstrual period date and date of delivery and categorized as preterm (<37 weeks) and term (≥37 weeks), as well as analyzed as a continuous variable. Birth weight for gestational age z-score was based on US population reference percentiles of birth weight for singleton infants, stratified by infant sex (35). Z-scores in Oken et al. 2003 were calculated based on the distribution of birth weights for all live births born 22 to 44 weeks gestation in the US, 1999-2000, with a potential range of - 2.58 to 2.58. Birth weight for gestational age z-score was analyzed as a continuous variable, as well as categorized based on the percentile of birth weight for gestational age: <10th percentile (small for gestational age; SGA) and >90th percentile (large for gestational age; LGA).

Subject selection

During the study period, there were 515 pregnancies in the Hopkins Lupus Cohort, of which 431 were live births (Figure 1). More than one singleton live birth per patient was allowed in the analysis. Pregnancies without a weight measurement in the one year prior to the last menstrual period pre-pregnancy or during the first trimester, and/or without a weight measurement in the third trimester, were excluded. Of the 431 live births, 291 pregnancies had a weight measurement during the one year prior to pregnancy or during the first trimester, and of these, 211 pregnancies had an additional weight measurement during the third trimester.

Analysis

Adherence to the IOM recommendations was classified as a categorical variable (inadequate, adequate or excessive weight gain) based on pre-pregnancy BMI. The percent of women who had inadequate, adequate or excessive weight gain, based on their pre-pregnancy BMI group was estimated, and the mean estimated total weight gain was calculated. An exploratory analysis determined factors associated with not meeting IOM guidelines by Fisher's exact test of differences in proportions and ANOVA compared differences in means. A generalized logit model analysis with stepwise selection determined predictors of inadequate and excessive weight gain, both compared to adequate weight gain. Generalized estimating equation methods were used to account for the potential correlation of multiple pregnancies per patient being included in the analysis (36). Potential variables were entered into the model if α was <0.2 and remained in the model if α was <0.05. Covariates included in model were race, education, infant delivery year, age at conception, duration of SLE, medication use ever during pregnancy (anti-malarial, immunosuppressants, prednisone, and prednisone ≥15 mg/day), SDI at conception and clinical characteristics ever occurring during pregnancy (renal involvement, elevated serum creatinine, high PGA, low complement, and anti-dsDNA).

Weight trajectories for gestational weight gain were estimated using mixed models. Mixed models include fixed and random effects and are ideal for repeated measures with varying number of measurements and time between measurements per subject (37). The model included a random effect for the intercept and for time (weeks of gestation). The fixed effects included a linear effect for time, quadratic effect for time, BMI group, and interaction for BMI group and time. All analyses were conducted with SAS 9.3 (Cary, North Carolina).

RESULTS

There were 211 pregnancies among 182 women included in the analysis. The majority of women were white (59%), with a median age at pregnancy of 30 years and median disease duration of 5 years. Overall, 34% of women had inadequate weight gain, 24% had adequate weight gain, and 42% had excessive weight gain (Figure 2). Differences were observed by pre-pregnancy BMI. Among underweight women, 67% of pregnancies had inadequate GWG and 33% had adequate GWG. Among normal weight women, pregnancies were fairly evenly divided, with 30%, 32% and 38% having inadequate, adequate and excessive weight gain, respectively. On the other hand, among overweight and obese women, few had inadequate GWG, 51% of both groups had excessive GWG, and only 19% and 7% of overweight and obese women, respectively, gained within the recommended guidelines. There were nine pregnancies in which the mother lost weight, ranging from 1.5 kg to 16.0 kg; all had BMI in the range of overweight or obese. The mean (SD) estimated total weight gain was 10.9 (3.4) kg for underweight women, 14.7 (6.4) for normal weight women, 12.9 (8.8) for overweight women, and 8.3 (12.4) for obese women.

In exploratory analyses, there were observed differences in adherence to IOM guidelines by race, elevated creatinine during pregnancy, pre-pregnancy blood pressure, and pre-pregnancy BMI (Table 1). The mean pre-pregnancy BMI for patients with inadequate, adequate and excessive weight gain was 26.9 kg, 23.4 kg, and 26.6 kg, respectively (p=0.004). Of interest,

there were no differences in weight gain adherence to IOM guidelines by SLE medication use during pregnancy and adherence to GWG guidelines did not appear to correlate with pregnancy outcomes.

In exploratory analyses, no differences in guideline adherence were observed for infants who were small for gestational age (SGA) compared to infants who were not SGA (p=0.2), for infants who were large for gestational age (LGA) compared to infants who were not LGA (p=0.8), or for infants who were preterm compared to term (p=0.6). The mean gestational age at birth (p=0.2) and birthweight percentile (p=0.07) were both similar across levels of guideline adherence.

In logistic regression models, stepwise selection determined continuous pre-pregnancy BMI and maternal education level were predictors of inadequate and excessive weight gain (Table 2). With each 1 kg/m^2 increase in pre-pregnancy BMI, the odds of inadequate weight gain and excessive weight gain both increased 12%. Compared to patients with a greater than college education, patients with a high school education had approximately three times the odds of inadequate weight gain and twice the odds of excessive weight gain.

Figure 3 illustrates the mean predicted change in maternal weight, stratified by pre-pregnancy BMI category (underweight, normal weight, and overweight). Normal weight and underweight women were pooled into one category due to the small number of underweight women. The weight gain trajectory did not change in a sensitivity analysis removing underweight women from the analytic cohort. The weight gain trajectories in normal weight/underweight women and overweight women appear to be similar, with weight increasing steadily throughout pregnancy. The trajectories for obese women, however, were different from normal weight/underweight and overweight women, with a decrease in weight observed at the beginning of pregnancy.

DISCUSSION

In this study of pregnant women with SLE, 34% of pregnancies had inadequate weight gain 24% of pregnancies had adequate weight gain, and 42% had excessive weight gain, rates similar to those observed in the general population of pregnant women in the United States (38). In a recent analysis of the Pregnancy Risk Assessment Monitoring System (PRAMS) 2010-2011, 21%, 32%, and 47% of women reported having inadequate weight gain, adequate weight gain, and excessive weight gain during pregnancy, respectively (38). In PRAMS, underweight women and normal weight women had decreased odds versus excessive weight gain, while overweight and obese women had increased odds of excessive weight gain (38, 39). Similar patterns were observed in our cohort of SLE women, with the frequency of excessive weight gain lower in normal weight and underweight women than overweight and obese women.

In exploratory analyses, some demographic and clinical characteristics were found to be associated with gestational weight gain, but in adjusted models, only pre-pregnancy BMI and maternal education were found to predict gestational weight gain. The demographic differences observed in our study, increased frequency of inadequate weight gain among

black patients compared to non-black patients and increased frequency of inadequate weight gain among patients with a high school education compared to more than a college education, have also been reported in the general population (38).

In the general population, a previous study has reported that among normal weight women, there is an increased odds of excessive weight gain in patients with hypertensive conditions (38). In our exploratory analysis, we also observed differences by pre-pregnancy blood pressure, with an increased frequency of both inadequate and excessive weight gain among patients with intermediate and poor pre-pregnancy blood pressure compared to patients with ideal pre-pregnancy blood pressure.

In exploratory analyses, a difference was observed in IOM guideline adherence for patients who had elevated creatinine during pregnancy compared to patients who did not. Although the number of patients with elevated creatinine was small (n=15), 53% of these patients had inadequate weight gain compared to 33% of patients without elevated creatinine, and 0% had adequate weight gain, compared to 26% of patients without elevated creatinine. Elevated creatinine indicates renal insufficiency (40). While we did not observe any differences in guideline adherence for patients with and without renal involvement during pregnancy, it appears that patients with elevated creatinine during pregnancy are at particular risk for not adhering to recommended guidelines, which may warrant further investigation.

Of particular interest was the lack of association of SLE medication use during pregnancy and gestational weight gain in exploratory analyses, including prednisone use or use of high prednisone dose (≥15 mg/day). This is in contrast to what was expected, given that prednisone has been found to increase adipose tissue among users (41). Only 21 of the 102 pregnancies with maternal exposure to prednisone initiated prednisone treatment during pregnancy. It may be that no increased frequency of excessive gestational weight gain with prednisone use was observed because patients have already experienced the increase in body mass associated with prednisone use, and no additional weight increases occurred during pregnancy.

Results from weight trajectory analyses suggest that the change in weight throughout pregnancy is similar for underweight, normal weight, and overweight women, but varies for obese women. Among obese women, weight appears to decrease during the 1st trimester and then increase at the start of the 2nd trimester. This is of interest, as weight measurements for women in this study were based on clinic measurements rather than self-report. Therefore, the weight fluctuations suggest a true initial decrease in weight and variability in weight gain among obese women, rather than an observed bias due to inaccurate reporting pre-pregnancy weight that may occur with self-reported weights.

Previous research has found that factors associated with non-adherence, such as race, education and certain co-morbidities vary by BMI group (38). A limitation of the present analysis is that the sample size of 211 women did not provide sufficient power to analyze interactive effects of BMI with demographic and clinical factors. Such analyses of interactive effects may help provide additional clarity on the unexpected results of no difference in guideline adherence by maternal prednisone use during pregnancy, which we

were unable to discern due to the limited sample size. Additionally, estimated due date was calculated for each patient based on last menstrual period, rather than early ultrasound, which may have miscalculated the correct estimated due date by one to two weeks. Finally, data were unavailable on patients' physical activity and diet, which may help further explain differences in weight gain patterns in this population.

Despite these limitations, our study was strengthened by the prospective collection of clinically recorded weights, rather than relying on self-report of pre-pregnancy weight of total gestational weight gain by the patient, which has been found to often be inaccurately remembered at the time of delivery (42). Additionally, the present analysis benefits from weights being measured at multiple times during pregnancy, with a median of 4 visits per patient, which allowed for weight gain trajectories to be constructed. Although the sample size is modest, this study reports one of the largest cohorts of pregnant women with SLE, and it is the first study to analyze gestational weight gain patterns in SLE.

The results of this analysis show that the majority of women with SLE do not meet the IOM guidelines for gestational weight gain. Pre-pregnancy BMI was found to be associated with not meeting guidelines in this study population, which is similar to what is observed in the general population. Targeted interventions to increase patient awareness about GWG guidelines and improve BMI prior to women with SLE becoming pregnant are important next steps for rheumatologists and obstetricians treating SLE patients to adopt in order to improve guideline adherence. Given that women with SLE are encouraged to seek pre-conception counseling with their physician to insure that disease activity is properly controlled and medications being taken are safe during pregnancy, this pre-conception visit would be an ideal time for a discussion about the IOM guidelines for weight gain and the implications of not adhering to the guidelines. Additionally, as BMI was found to be an important predictor of non-adherence to weight gain guidelines in our study, this pre-conception visit would also provide the opportunity to discuss a patient's current BMI and encourage the patient to be within the normal BMI range prior to becoming pregnant.

It has yet to be determined if the IOM guidelines for weight gain in the general population are appropriate for women with SLE, and future studies are necessary to determine if pregnancy outcomes in women with SLE are improved when IOM guidelines for gestational weight gain are met. As research in the general population has shown that adherence to IOM guidelines has significant implications for the future health of both the mother and infant, it is important to further understand what factors may be associated with non-adherence to guidelines in women with SLE. Physicians are encouraged to share the IOM physician toolkit for gestational weight gain (available at www.nationalacademies.org) with their patients in order to promote proper weight gain during pregnancy.

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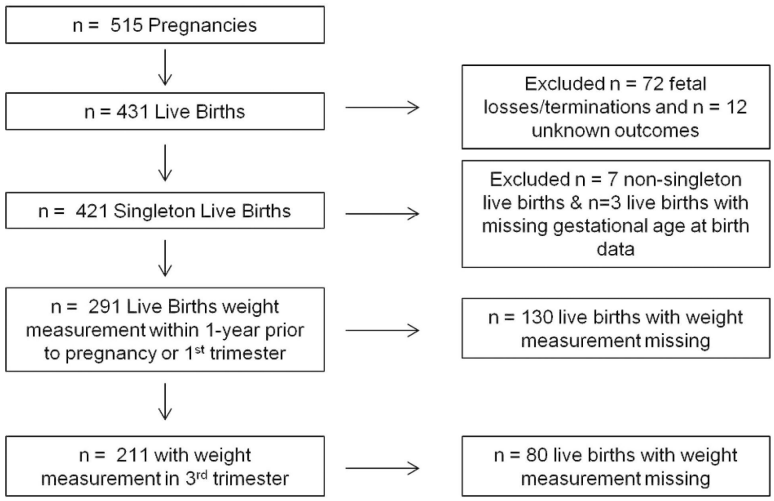

Figure 1.

Study population for the Hopkins Lupus Pregnancy Cohort, 1987 to February 2015.

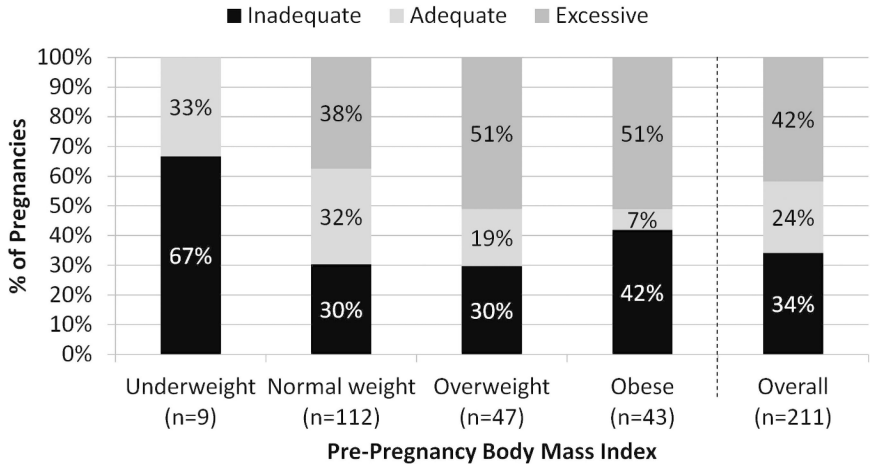

Figure 2.

Proportion of pregnancies with systemic lupus erythematosus meeting Institute of Medicine recommendations for gestational weight gain based on maternal pre pregnancy body mass index[a] in the Hopkins Lupus Pregnancy Cohort (n=211)

[a]Pre pregnancy body mass index classified as underweight (<18.5 kg/m^2), normal weight (18.5 24.9 kg/m^2), overweight (25.0 29.9 kg/m^2), and obese (≥30 kg/m^2)

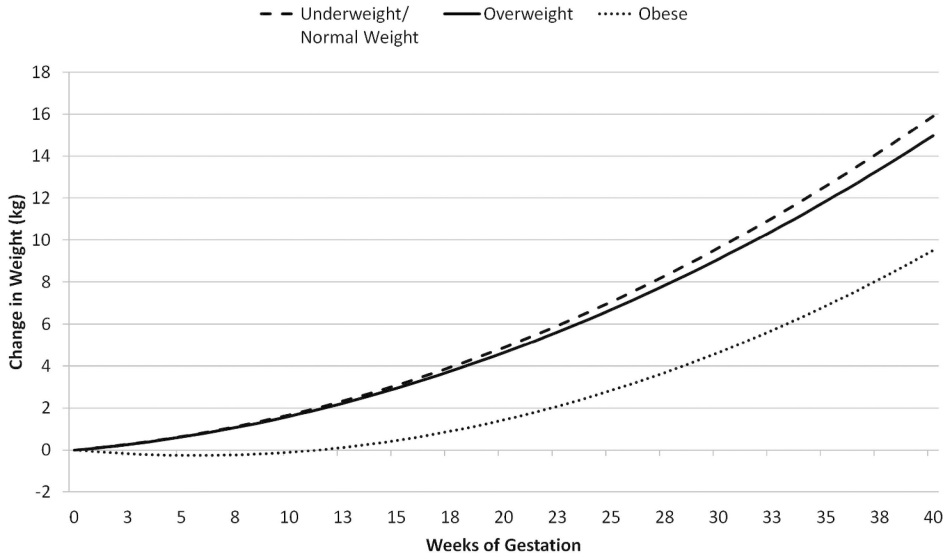

Figure 3.

Mean predicted change in weight during pregnancy from mixed effects models with a random effect for individuals[a], stratified by pre-pregnancy BMI[b] for women with SLE in the Hopkins Lupus Pregnancy Cohort (n=211).

[a]Mean weight change = 4.3358 + 0.3928(gestational age) + 0.0077 (gestational age^2) − 0.5002 (overweight) − 3.1870 (obese) − 0.0223(gestational age × overweight) − 0.1603(gestational age × obese) 0.0005 (gestational age^2 × overweight) + 0.0005 (gestational age^2 × obese)

[b]underweight and normal weight women were combined due to small sample size

Table 1

Demographic and clinical factors associated with estimated total weight gain during pregnancy for women with SLE in the Hopkins Lupus Pregnancy Cohort (n=211)

	n	Inadequate n (%)	Adequate n (%)	Excessive n (%)	Fisher X^2 p-value
Race					
Non-Black	146	41 (28.1%)	39 (26.77%)	66 (45.2%)	0.02
Black	65	31 (47.7%)	12 (18.5%)	22 (33.9%)	
Age					
≤30	101	34 (33.7%)	26 (25.7%)	41 (40.6%)	0.9
>30	110	38 (34.6%)	25 (22.7%)	47 (42.7%)	
Education					
HS Education (≤12 years)	57	25 (43.9%)	9 (15.8%)	23 (40.4%)	0.2
College (13-16 years)	100	34 (34.0%)	24 (24.0%)	42 (42.0%)	
Greater than College (>16 years)	54	13 (24.1%)	18 (33.3%)	23 (42.6%)	
SLE Duration					
≤5 years	101	33 (32.7%)	23 (22.8%)	45 (44.6%)	0.7
>5 years	110	39 (35.4%)	28 (25.5%)	43 (39.1%)	
Prednisone Use During Pregnancy					
No	109	35 (32.1%)	29 (26.6%)	45 (41.3%)	0.7
Yes	102	37 (36.3%)	22 (21.6%)	43 (42.2%)	
Prednisone Use ≥15 mg/day During Pregnancy among Prednisone Users (n=102)					
No	54	18 (33.3%)	10 (18.5%)	26 (48.2%)	0.4
Yes	48	19 (39.6%)	12 (25.0%)	17 (35.4%)	
Anti-malarial Use During Pregnancy					
No	59	19 (32.2%)	12 (20.3%)	28 (47.5%)	0.5
Yes	152	53 (34.9%)	39 (25.7%)	60 (39.5%)	
Immunosuppressants Use During Pregnancy					
No	174	61 (35.1%)	44 (25.3%)	69 (39.7%)	0.5
Yes	37	11 (29.7%)	7 (18.9%)	19 (51.4%)	
Highest PGA During Pregnancy					
<2	175	61 (34.9%)	44 (25.1%)	70 (40.0%)	0.6
≥2	36	11 (30.6%)	7 (19.4%)	18 (50.0%)	
SDI at Conception					
0	132	41 (31.1%)	37 (28.0%)	54 (40.9%)	0.2
≥1	79	31 (39.2%)	14 (17.7%)	34 (43.0%)	
Renal Involvement During Pregnancy					
No	151	51 (33.8%)	38 (25.2%)	62 (41.1%)	0.9
Yes	60	21 (35.0%)	13 (21.7%)	26 (43.3%)	
Elevated Creatinine During Pregnancy					
No	196	64 (32.7%)	51 (26.0%)	81 (41.3%)	0.03

	n	Inadequate n (%)	Adequate n (%)	Excessive n (%)	Fisher X^2 p-value
Yes	15	8 (53.3%)	0 (0.0%)	7 (46.7%)	
Low C3 During Pregnancy					
No	160	54 (33.8%)	33 (20.6%)	73 (45.6%)	0.06
Yes	51	18 (35.3%)	18 (33.3%)	15 (29.4%)	
Low C4 During Pregnancy					
No	135	45 (33.3%)	28 (20.7%)	62 (45.9%)	0.2
Yes	76	27 (35.5%)	23 (30.3%)	26 (34.2%)	
Anti-dsDNA+ During Pregnancy					
No	128	40 (31.3%)	33 (25.8%)	55 (43.0%)	0.5
Yes	83	32 (38.6%)	18 (21.7%)	33 (39.8%)	
Pre-Pregnancy Blood Pressure					
Ideal	105	31 (29.5%)	34 (32.4%)	40 (38.1%)	0.02
Intermediate/Poor	106	41 (38.7%)	17 (16.0%)	48 (45.3%)	
Pre-Pregnancy Total Cholesterol					
Ideal	178	57 (32.0%)	44 (24.7%)	77 (43.3%)	0.9
Intermediate/Poor	22	5 (22.7%)	8 (36.4%)	9 (40.9%)	
Pre-Pregnancy BMI, kg/m^2					
Under weight (<18.5)	9	6 (66.7%)	3 (33.3%)	0 (0.0%)	0.001
Normal weight (18.5-24.9)	112	34 (30.4%)	36 (32.1%)	42 (37.5%)	
Overweight (25.0-29.9)	47	14 (29.8%)	9 (19.2%)	24 (51.1%)	
Obese (≥30)	43	18 (41.9%)	3 (7.0%)	22 (51.2%)	
Infant birth date					
January 1999 – February 2015	156	49 (31.4%)	39 (25.0%)	68 (43.6%)	0.4
Prior to January 1999	55	23 (41.8%)	12 (21.8%)	20 (36.4%)	
Small for gestational age (n=198)					
No	159	57 (35.9%)	32 (20.1%)	70 (44.0%)	0.2
Yes	39	12 (30.8%)	13 (33.3%)	14 (35.9%)	
Large for gestational age (n=198)					
No	190	67 (35.3%)	43 (22.6%)	80 (42.1%)	0.8
Yes	8	2 (25.0%)	2 (25.0%)	4 (50.0%)	
Preterm birth					
No	160	52 (32.5%)	41 (25.6%)	67 (41.9%)	0.6
Yes	51	20 (39.2%)	10 (19.6%)	21 (41.2%)	
Pregnancy induced hypertension (n=162)					
No	150	48 (32.0%)	32 (21.3%)	70 (46.7%)	0.3
Yes	12	6 (50.0%)	3 (25.0%)	3 (25.0%)	
Pre-eclampsia (n=166)					
No	151	48 (31.8%)	34 (22.5%)	69 (45.7%)	0.5
Yes	15	7 (46.7%)	2 (13.3%)	6 (40.0%)	
Caesarian section (n=166)					

	n	Inadequate n (%)	Adequate n (%)	Excessive n (%)	Fisher X^2 p-value
No	103	39 (37.9%)	22 (31.4%)	42 (40.8%)	0.3
Yes	63	17 (27.9 %)	14 (22.2%)	32 (50.8%)	
Premature rupture of membranes (n=164)					
No	146	49 (33.6%)	32 (21.9%)	65 (44.5%)	0.9
Yes	18	5 (22.8%)	4 (22.2%)	9 (50.0%)	
		Mean (SD)	**Mean (SD)**	**Mean (SD)**	**ANOVA p-value**
Age at conception, years	211	30.3 (5.1)	30.5 (5.0)	30.0 (4.4)	0.8
Disease duration, years	211	6.5 (5.3)	7.4 (5.8)	6.2 (5.6)	0.5
Highest PGA during pregnancy	211	1.0 (0.7)	0.9 (0.7)	1.1 (0.7)	0.4
SDI at conception	211	0.9 (1.4)	0.4 (0.8)	0.8 (1.5)	0.2
Highest daily prednisone dose during pregnancy among prednisone users, mg	102	21.0 (17.1)	16.5 (12.7)	15.5 (13.3)	0.2
Pre-pregnancy BMI, kg/m^2	211	26.9 (7.4)	23.4 (4.4)	26.6 (5.7)	0.004
Gestational age at birth, weeks	211	37.1 (2.6)	37.6 (1.8)	37.6 (2.0)	0.2
Birth weight percentile	198	31.3 (23.8)	31.4 (26.6)	40.1 (27.1)	0.07
Birth weight z-score	198	−0.63 (0.84)	−0.65 (0.96)	−0.36 (0.97)	0.1

BMI: body mass index; HS: high school; PGA: physician global assessment of disease activity; SD: standard deviation; SDI: SLICC/ACR Damage Index; SLE: systemic lupus erythematosus

Table 2

Predictors of adherence to 2009 IOM guidelines for gestational weight gain[a] for women with SLE in the Hopkins Lupus Pregnancy Cohort (n=211).

	Inadequate	Excessive
	OR (95% CI)	**OR (95% CI)**
Education		
HS Education (≤12 years)	3.31 (1.12, 9.75)	1.74 (0.62, 4.90)
College (13-16 years)	2.05 (0.79, 5.32)	1.40 (0.63, 3.13)
Greater than College (>16 years)	1.0 (ref)	1.0 (ref)
Pre-pregnancy BMI, kg/m^2	1.12 (1.03, 1.22)	1.12 (1.03, 1.21)

[a]Stepwise selection: entered into model if $\alpha < 0.2$; remained in model if $\alpha < 0.05$