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# Early pregnancy weight gain exerts the strongest effect on birth weight, posing a critical time to prevent childhood obesity

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## Abstract

**Objective—**Gestational weight gain (GWG) is associated with infant birth weight and childhood obesity; however, the patterns of GWG on infant birth weight are poorly understood.

**Method—**This analysis in 16,218 mother-child dyads from Tianjin, China determined the risk of infant size at birth according to GWG occurring throughout the first and second trimester (early GWG), or during the third trimester (late GWG), according to maternal pre-pregnancy BMI and the 2009 IOM recommendations.

**Results—**Excessive GWG in early and late pregnancy had the highest risk for large for gestational age (LGA) infants (OR 2.4; 95% CI 1.5–4.0, p<0.001). Regardless of pre-pregnancy BMI, excessive GWG early in pregnancy (<24 weeks), was associated with a higher risk of LGA infants (OR 2.5; CI 2.1–3.1, p<0.001), and inadequate early GWG was associated with a higher risk of small for gestational age (SGA) infants (OR 1.4; 95% CI 1.2–1.7, p<0.001).

**Conclusion—**The pattern of GWG early in pregnancy, regardless of GWG later in pregnancy, had the greatest impact on infant size at birth. Interventions initiated early in pregnancy may facilitate better adherence to the GWG guidelines and minimize the risk of LGA and SGA infants, a potential precursor for childhood obesity.

### Keywords

pregnancy; gestational weight gain; childhood obesity



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## Introduction

Obesity prevalence continues to rise worldwide and women of childbearing age are not an exception (1). The recent increase in maternal pre-pregnancy body mass index (BMI) has brought to light a number of studies showing that infant outcomes are worsened with increasing degrees of maternal BMI at conception (2, 3). Gestational weight gain (GWG) also influences infant outcomes such as increased risks of preterm birth, macrosomia and childhood obesity (4, 5). Due to the significant healthcare costs required to manage these untoward outcomes (6), greater attention is being directed toward preventative measures including the development and testing of interventions to better manage GWG in pregnant women.

Although excessive and/or inadequate total GWG can influence neonatal outcomes, recent observations suggest that the timing of this GWG may also be important. A study of 650 pregnant women who were primarily African American, low-income, and obese, first identified this hypothesis and reported that in comparison to women with adequate GWG throughout pregnancy, excess GWG prior to 20 weeks, regardless of the weight change later in pregnancy, significantly increased the risk of large for gestational age (LGA) infants (7). Furthermore, a physical activity intervention for healthy management of GWG found that neonates born to women with excessive GWG early in pregnancy (< 20 weeks) were not only heavier at birth, but had more body fat compared to neonates exposed to excessive GWG only late in pregnancy or adequate GWG throughout pregnancy (8). These studies suggests the a-priori hypothesis that GWG early in pregnancy may exert the largest influence on intrauterine programming of infant size at birth. However, these findings are limited and there is a need to further explore this hypothesis with larger cohorts. The aim of the present study was therefore to utilize a well-described cohort (2, 5) of more than 16,000 pregnant women and infants to evaluate the effect of early versus late GWG on infant size at birth.

## Methods

Electronic healthcare records for both pregnant women and infants were collected from Women and Children's Health Center system of Tianjin, China between June 2009 and May 2011 (2, 9, 10). Prenatal care was established within the first 12 weeks of pregnancy and abstracted records included general patient information (age, occupation, education, date of first visit, numbers of pregnancy/infants, last menstrual period, expected delivery date, smoking habits), maternal and family history of disease, clinical measurements (height, weight, blood pressure, gynecological examinations, ultrasonography, GDM screening test), pregnancy outcomes (delivery mode, labor complications), and postnatal exams occurring <42 days after delivery (2, 10). Pediatric health records include information from neonates (date of birth, sex, gestational weeks of birth, birth weight, birth recumbent length, Apgar score, etc), family history of diseases and feeding modality (10). Between June 2009 and May 2011, all available maternal and pediatric records were abstracted (n=66,285). Application of a-priori exclusion criteria to exclude records with missing data pertinent for our analysis plan; multiple gestation (n=506), missing the complete set of maternal weight data (n=46,547), and missing mother-infant pairs data required for this analysis (n=3,014), revealed 16,218 mother-infant dyads with complete data and clinical measurements for this analysis. The maternal and infant characteristics were not different between the entire set of extracted data and the complete dataset used in this analysis.

The present study included 16,218 records for live-birth infants born between June 2009 and May 2011 mother-infant dyads with complete data and clinical measurements. The study and analysis plan was approved by the Tianjin Women's and Children's Health Center Institutional Review Board.

## Clinical Measurements

Specially trained gynecologists in the hospital system obtained anthropometric data of mothers during pregnancy using the same devices. Weight and height were measured on a balance beam scale in light clothing and no shoes (RGZ-120, Jiangsu Suhong Medical Instruments Co., China). Birth weight was measured to the nearest 0.01kg using a digital scale (TCS-60, Tianjin Weighing Apparatus Co., China). Length was measured to the nearest 0.1cm using a recumbent length stadiometer (YSC-2, Beijing Guowangxingda, China). Internal validity comparing the electronic data of birth weight (n=454) and maternal height and weight (n=200) found a high level of agreement with the hospital measurement, r= 0.991, 0.998 and 0.997, respectively.

Pre-pregnancy BMI was calculated using the measured weight (baseline weight) and height recorded at the first prenatal visit occurring within the first 12 weeks of gestation. This was used to categorize women as underweight (BMI<18.5 kg/m$^2$), normal-weight (18.5 kg/m$^2$≤ BMI <24.0 kg/m$^2$), overweight (24.0 kg/m$^2$≤ BMI<28.0 kg/m$^2$), or obese (BMI ≥28.0 kg/m$^2$) using Chinese classifications (11). Pre-pregnancy weight is often inferred when the first measured weight in pregnancy occurs in the first trimester and several groups have demonstrated good validity and a high correlation (0.95, p=0.0001) between first measured weight in pregnancy and pre-pregnancy weight (12, 13). The decision to use the Chinese (or Asian) classification for BMI is guided by a WHO report advising to lower cutoff points for Chinese populations (14). Lower BMI cut-off points for Asians who are overweight or obese are required since the observed disease risk in these different populations occurs at 22–25 kg/m$^2$ (overweight) and for high risk 26–31 kg/m$^2$ (obese).

Total GWG was calculated as the difference between pre-pregnancy and delivery weight. The second trimester pregnancy weight gain, defined in this study as 'early GWG' was calculated as the difference between the first measured weight recorded in the first trimester (<12 weeks) and the weight measured between 24–27 weeks. The third trimester pregnancy weight gain, defined as 'late GWG' was calculated as the difference between weight measured at weeks 24–27 and weight measured at 32–36 weeks. The adequacy of GWG was defined for each woman according to the Chinese maternal pre-pregnancy BMI classification and the 2009 IOM recommendations (1): 12.5–18kg (pre-pregnancy BMI<18.5g/m$^2$), 11.5–16kg (BMI 18.5–23.9kg/m$^2$), 7–11.5kg (BMI 24.0–27.9kg/m$^2$), and 5–9 kg (BMI >28kg/m$^2$) and adjusted for the length of gestation (15). The adequacy of rates of weight gain during the 2nd and 3rd trimesters were defined according to the Chinese maternal prepregnancy BMI status and the 2009 IOM GWG recommendations (1): 0.453592–0.589670 kg (prepregnancy BMI <18.5 kg/m$^2$), 0.362874–0.453592 kg (BMI

18.5– 23.9 kg/m$^2$), 0.226796–0.317515 kg (BMI 24.0–27.9 kg/m$^2$), and 0.181437–0.272155 kg (BMI >28 kg/m$^2$). We used the translation of US IOM GWG recommendations because no official recommendations exist in China.

Small for gestational age (SGA) infants were identified as a standardized birth weight <10th percentile, whereas LGA infants were identified as a standardized birth weight >90th percentile. Infants who were appropriate for gestational age in the existing population were used as the standard. Low birth weight was defined as <2500g and macrosomia as birth weight ≥4000g.

### Statistical analyses

Characteristics of mothers and children based on maternal pre-pregnancy BMI and GWG at early and late gestation were compared using the General Linear Models and chi-square tests. Logistic regression was used to assess the single and joint associations of maternal pre-pregnancy BMI and early GWG and late GWG with the risks of infant birth outcomes. All models included maternal age, height, education, smoking, occupation, family income and gestational age as covariates. The trend over different categories of maternal pre-pregnancy BMI and GWG categories was tested in each model by giving an ordinal numeric value for each dummy variable. All statistical analyses were performed with PASW for Windows, version 21.0 (Statistics 21, SPSS, IBM, USA).

## Results

Of the 16,218 mothers studied (Table 1), 12% were underweight, 64% normal weight, 18% overweight, and 6% were obese prior to pregnancy. In accordance with the IOM guidelines there was an inverse relationship between pre-pregnancy BMI and total GWG (Figure 1). Mothers with obesity gained the least amount of total weight in early and late pregnancy (7.1±3.7 kg and 3.7±2.3 kg, respectively) when compared to overweight (8.2±3.4 kg and 4.1±2.2 kg), normal weight (8.8±3.1 kg and 4.4±2.2 kg), and underweight (8.8±2.8 kg and 4.3±2.0 kg) mothers ($p<0.001$).

### Gestational Weight Gain

The weight used to calculate GWG in early and late pregnancy was first measured between 2–13 weeks of gestation (mean GA 11.0±1.7w), between 24–27 weeks of gestation (mean GA 25.7±1.0w) and the final weight measurement was recorded between 32–36 weeks of pregnancy (mean GA 32.4±0.9w). Figure 1 shows the total (Panel A) and rate of GWG stratified by the IOM guidelines in each pre-pregnancy BMI group and for both early (Panel B) and late pregnancy (Panel C). Considering all mothers together, those with excess GWG had the highest rate of GWG which was two-to-three times higher than mothers with inadequate GWG ($p<0.001$). Mothers with excess early GWG had the highest rate of GWG which was 37% and 61% higher than mothers with adequate and inadequate GWG early in pregnancy (0.7±0.2 kg/w, 0.4±0.1 kg/w, and 0.3±0.1 kg/w, $p<0.001$), respectively. Mothers with excess early GWG also had the highest rate of GWG during late pregnancy than mothers with adequate or inadequate early GWG (0.7±0.3 kg/w, 0.6±0.3 kg/w, and 0.6±0.3 kg/w, $p<0.001$, respectively).

Early in pregnancy, GWG was inadequate in 12% (n=1,966), adequate in 13% (n=2,147) and excessive in 75% (n=12,105) of mothers. Similarly, in late pregnancy, 13% (n=2,183) had inadequate GWG, 10% (n=1,579) had adequate GWG, and 77% (n=12,456) had excess GWG according to the IOM guidelines. Mothers with excess early GWG had a total GWG that was greater than for mothers with either adequate or inadequate GWG early in pregnancy (14.1±3.5, 10.5±2.6, 8.2±2.9, kg, p<0.001, respectively). Similarly, mothers who exceeded the IOM guidelines late in pregnancy had a total GWG that was greater than for mothers who had adequate or inadequate GWG in late pregnancy (13.7±3.7, 10.9±3.2, 9.7±3.4, kg, p<0.001, respectively).

### Effect of Early and Late GWG on Infant Birth Weight

**Effect of early GWG—**In all analyses, the reference group was mothers with a normal pre-pregnancy BMI and adequate GWG in early and/or late pregnancy. In comparison to normal weight mothers prior to pregnancy (Figure 2, Panel A), infants born to underweight mothers were 1.7 times [95% confidence interval (CI) 1.5–2.0] more likely to be SGA (p<0.001) compared to infants born from mothers who were overweight (OR: 0.7; CI 0.6–0.9, p<0.001) and obese (OR: 0.55; CI 0.4–0.7, p=0.005). Compared to infants born from mothers with adequate early GWG, infants born to mothers with inadequate early GWG had a 40% increase (OR 1.4; CI 1.2–1.7, p<0.001) in being born SGA whereas infants born to mothers with excessive early GWG had a decreased likelihood of being SGA at birth (OR: 0.54; CI 0.5–0.6, p<0.001). For early GWG and LGA (Figure 2, Panel B), infants born to mothers with obesity were 3 times more likely (OR: 3.0 CI 2.5–3.6, p<0.001) of being born LGA compared to infants born to mothers who were overweight (OR 1.7; CI 1.5–1.9, p=0.001) or underweight (OR: 0.34; CI 0.3–0.4, p=0.002). Infants born to mothers with adequate early GWG were 50% less likely to be LGA than infants born to mothers with excessive early GWG (OR: 1.5; CI 1.3–1.9, p=0.001). Infants born to mothers with inadequate early GWG did not have an increased risk of being born LGA (OR 1.1; CI 0.9–1.4, p=0.239). This same pattern of early GWG was evident for both low birth weight and macrosomia, respectively (data not shown).

**Effect of late GWG—**Considering only maternal pre-pregnancy BMI, infants born to mothers who were underweight prior to pregnancy had a 70% increased risk for being born SGA (CI: 1.5–2.0, p=0.01), whereas no risk existed for infants born to mothers who were overweight (OR: 0.72; CI 0.6–0.9, p=0.76) and obese (OR: 0.55; CI 0.4–0.7, p=0.79), Figure 3, Panel A. Conversely, the risk of an infant being born LGA was positively associated with maternal BMI prior to pregnancy (p<0.001), Figure 3, Panel B. Infants born to mothers with obesity had a 3-fold increase of being born LGA (OR: 3.0; CI 2.5–3.6, p<0.001), whereas no increased risk existed for infants born to overweight mothers (OR: 1.7; CI 1.5–1.9, p=0.87) or underweight mothers (OR: 0.34; CI 0.3–0.4, p=0.16). Considering the pattern of late GWG, in comparison to mothers with adequate late GWG, infants born to mothers with excessive later GWG were 150% (OR: 2.5; CI 1.1–3.1) more likely to be born LGA (p<0.001), whereas infants born to mothers with inadequate late GWG slightly reduced the risk for being born LGA (OR: 0.9; CI 0.7– 1.2, p<0.001). These patterns had the same effect on the risk for infants being born with macrosomia and low birth weight (data not shown).

**Patterns of GWG across the entire pregnancy—**Infants born to mothers with inadequate GWG in both early and late pregnancy (OR: 2.0; CI: 1.3–3.0, p=0.001) had the greatest risk of being born SGA (Figure 4, Panel A) whereas mothers with inadequate early GWG but excessive late GWG only had a 15% increased risk of their infant being born SGA (OR: 1.2; CI: 0.8–1.6). In contrast, infants born to mothers with excess GWG in both early and late (OR: 2.4; CI: 1.5–4.0) pregnancy had the highest risk (p=0.001) for being born LGA (Figure 4, Panel B) whereas infants born to mothers who had excessive early GWG followed by either inadequate (OR: 1.9; CI: 1.1–3.2) or adequate late GWG (OR: 1.7; CI: 1.0–3.0) had a reduced risk of being born LGA (p<0.001). Therefore, regardless of pre-pregnancy BMI, a U-shaped association between early GWG and infant birth weight is evident such that excessive early GWG was associated with a higher risk of LGA infants, whereas inadequate early GWG was associated with a higher risk of SGA infants. We observed the same findings for macrosomia and low birth weight, respectively (data not shown).

## Discussion

Timing of GWG has implications for the future health of women and children. We observed that GWG early in pregnancy which exceeds the IOM recommendations, regardless of the pattern of weight gain later in pregnancy, increases the risk of an infant born LGA or with macrosomia. Conversely, early GWG which is below the IOM recommendations increases the risk for having an infant born SGA; however, this effect was attenuated by increasing weight gain to optimal levels later in the pregnancy.

Historical examinations of weight gain in pregnancy conclude that very little weight gain occurs in the first trimester and weight thereafter increases linearly until delivery (1). Following the publication of the IOM recommendations for weight gain in pregnancy, the impact of total GWG on maternal and infant outcomes has received increasing attention (1). Epidemiological studies show that excessive GWG across the entire pregnancy increases the risk for LGA infants (16, 17) whereas inadequate GWG increases the risk for SGA infants (2, 4, 18), and our cohort concurs with these previous observations. Much less attention is attributed to the patterns of GWG and if weight gain early and/or late in pregnancy is more or less problematic. It has been suggested that a 2 pound weight gain in excess of the IOM guidelines in women with obesity during the first trimester is a strong predictor for excess GWG throughout pregnancy (19). Similar findings with excess weight gained even earlier at 8–12 weeks has also been reported (20, 21). Identifying the most important windows of GWG will allow prevention strategies to be better designed and targeted toward health outcomes in mothers and infants.

The present study suggests that early pregnancy is a vital period for ensuring that mothers receive advice and close monitoring of gestational weight gain. Longitudinal studies support this idea with reports that early GWG (between 0–20 weeks), is associated with a greater risk for childhood obesity (22, 23). Unfortunately, behavioral interventions with the goal to reduce total GWG and adverse outcomes in infants have achieved underwhelming results, particularly in women with obesity, where the impact of early and late GWG has the most profound effect on infant size at birth. For example, the Fit for Delivery Study which delivered a lifestyle intervention during pregnancy was successful in reducing GWG in normal weight women only (13). Similarly, the UPBEAT trial which enrolled women with obesity in a diet and physical activity intervention, found no effect on GWG between the intervention and control groups and no differences in prevalence of LGA infants (24). Of note, both of these large RCT initiated their interventions after week 16 of pregnancy and therefore if the hypothesis that early GWG programs infant size at birth is true, it appears that the critical window for the programming of neonatal size at birth and adiposity was missed in these studies. In support of this idea, the most successful intervention targeting GWG in women with obesity was initiated as early as 7 weeks and lead to a reduction in LGA and macrosomia in the offspring (25). Collectively, these intervention studies support the idea that women should receive counselling regarding optimal weight gain early in pregnancy, and ideally at the first prenatal appointment because this likely occurs in a critical window for neonatal size at birth.

One possible explanation for the increased risk for LGA with maternal obesity and excess GWG is that the infant metabolism in utero could be compromised by the obese milieu of the mother. Energy expenditure, one of the two major determinants of body weight has been shown to be lower in infants at 3 months of age born from mothers with obesity when measured over several days by doubly labeled water (26). The obvious maternal behavior that could contribute to excess GWG is changes in energy intake. Maternal energy intake in the early stages of pregnancy is usually prescribed as minimal increases of ~150 kilocalories/day to upwards of 350 into the second trimester (27). We used a publically available maternal energy intake calculator to estimate the energy intake in women in this study determined by the pre-pregnancy weight, height, and measured weights throughout the three trimesters (28). Using the mean data, the calculator suggests that those women who had excessive GWG early and late pregnancy were consuming ~200 kilocalories per day more than women in the reference group (those who had adequate GWG in both early and late pregnancy). Studies of the determinants of GWG in mother-infant dyads are warranted because the potential for developmental programming of energy intake and energy metabolism is not known and these factors probably play a key role in the development of postnatal adiposity in offspring.

The strength of this study was use of a large, well-characterized cohort of mother-infant dyads to explore GWG in early and late gestation and the use of the IOM rate of gain guidelines to classify weight gain rather than the use of total net weight gain. A limitation was that this study is limited to Chinese women, however; the women studied resided in both rural and urban regions and therefore would likely encompass varying levels of physical activity and patterns of dietary intake. Importantly routine obstetrical care in China is identical to the US with establishment care in the first trimester followed by monthly check-ups, then biweekly and finally weekly through to delivery. It should also be noted that the abstracted data included gestational diabetes and hypertension diagnosis, but not preeclampsia. We acknowledge that these pathologies can influence both GWG and infant size at birth, but due to low incidence in our cohort we did not explore these in regards to infant outcomes. Finally, all available maternal and pediatric records were initially abstracted from 66,285 women, but a final sample size of 16,218 records was used, which may influence the generalizability of some of the outcomes.

In summary, excess GWG early in pregnancy regardless of weight gain that occurs later increases the risk of LGA in the infant. Since this period of pregnancy could influence the development of increased adiposity in the child, this is the opportune time to initiate lifestyle interventions in pregnant women. Data on unintended pregnancy in the US suggests approximately 49% of pregnancies are unplanned (29) and therefore capturing couples who are planning pregnancy is a critical strategy for public health programs targeting inter-generational obesity prevention. Further, longitudinal research and lifestyle interventions are merited on infants born to mothers with excess GWG, specifically those mothers with excess GWG early in pregnancy to learn if this period is associated with more profound obesity in childhood. Finally, lifestyle interventions targeting women prior to pregnancy need to be developed and tested.

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**What is already known about this subject**

- Gestational weight gain can lead to adverse health outcomes for both the mother and offspring.
- Evidence is limited in a large cohort on how the patterns of gestational weight gain can lead to these adverse outcomes, particularly in the infant.

**What this study adds**

- The pattern of gestational weight gain early in pregnancy, regardless of gestational weight gain later in pregnancy has the greatest impact on infant size at birth.
- Excess gestational weight gain early in pregnancy leads to large for gestational age infants and may contribute to childhood obesity.

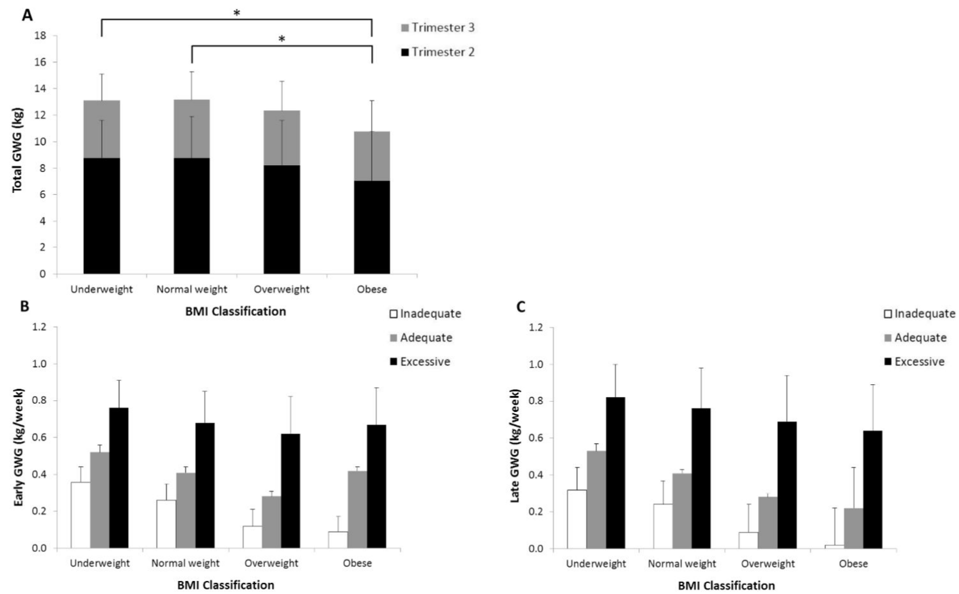


**Figure 1. Maternal characteristics of total gestational weight gain (GWG) by pre-pregnancy body mass index categories (Panel A), early (Panel B), and late (Panel C) GWG according to Institute of Medicine (IOM) guidelines and classified by body mass index (BMI) categories**

Pre-pregnancy BMI was used to categorize women as underweight (BMI <18.5 kg/m$^2$), normal-weight (18.5 kg/m$^2$ ≤ BMI <24.0 kg/m$^2$), overweight (24.0 kg/m$^2$≤ BMI <28.0 kg/m$^2$), or obese (BMI ≥28.0 kg/m$^2$). In Panel A, black bars are early gestational weight gain (difference between <12 weeks and 24–27 weeks) and gray bars are late gestational weight gain (difference between 24–27 weeks and 32–36 weeks). In Panels B and C, white bars are inadequate weight gain, gray bars are adequate, and black bars are excessive according to IOM guidelines. Error bars represent standard deviations. * = $p<0.05$.

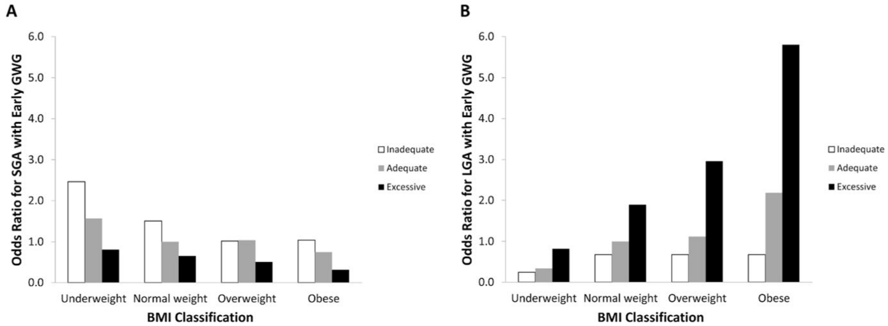


**Figure 2. Odd ratios of neonatal outcomes by maternal pre-pregnancy body mass index and early gestational weight gain (GWG) adjusted for maternal age, maternal height, maternal education, smoking, family income, and maternal occupation**

Panel A is small for gestational age (SGA) with early GWG and Panel B is large for gestational age (LGA) with early GWG. White bars are inadequate GWG, gray bars are adequate GWG, and black bars are excessive GWG.

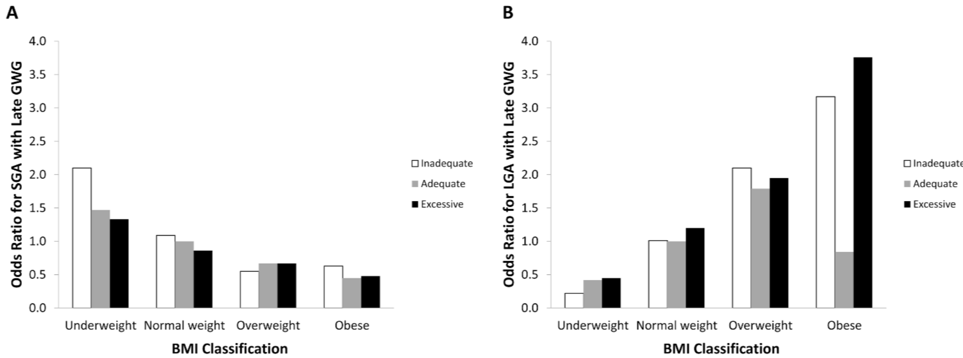


**Figure 3. Odd ratios of neonatal outcomes by maternal pre-pregnancy body mass index and late gestational weight gain (GWG) adjusted for maternal age, maternal height, maternal education, smoking, family income, and maternal occupation**

Panel A is small for gestational age (SGA) with late GWG and Panel B is large for gestational age (LGA) with late GWG. White bars are inadequate GWG, gray bars are adequate GWG, and black bars are excessive GWG.

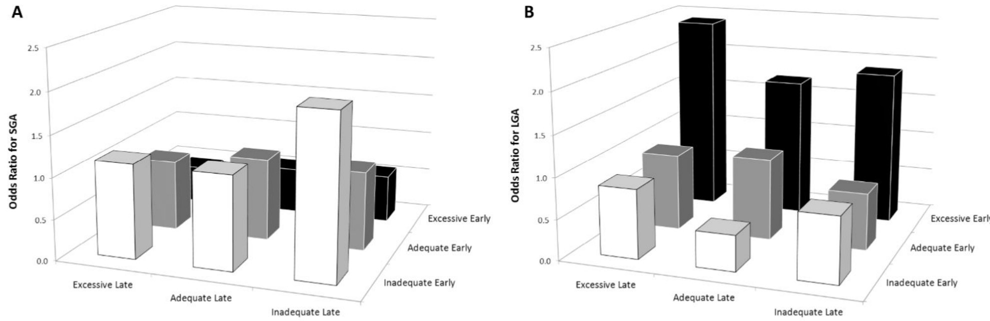


**Figure 4. Odd ratios of neonatal outcomes considering joint effects of gestational weight gain (GWG) in early and late pregnancy adjusted for maternal age, maternal height, maternal education, smoking, family income, and maternal occupation**

Panel A is small for gestational age (SGA) and Panel B is large for gestational age (LGA). Panel A is odds ratio of SGA by early versus late GWG. Panel B is odds ratio of LGA by early versus late GWG.

## Table 1

Characteristics of study participants among 16,218 mother-infant pairs according to maternal pre-pregnancy body mass index and gestational weight gain categories in Tianjin, China. Data is presented as mean ± standard deviation.

| | Prepregnancy body mass index (kg/m$^2$) | | | | *P* | Institute of Medicine categories at early weight gain | | | *P* | Institute of Medicine categories at later weight gain | | | *P* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | <18.5 | 18.5–23.9 | 24.0–27.9 | ≥28 | | Inadequate | Adequate | Excessive | | Inadequate | Adequate | Excessive | |
| No. of subjects | 1872 | 10,446 | 2982 | 918 | | 1966 | 2147 | 12,105 | | 2183 | 1579 | 12,456 | |
| **Maternal characteristics** | | | | | | | | | | | | | |
| Age, y | 26.8 (2.9) | 27.7 (3.1) | 28.1 (3.4) | 27.8 (3.3) | <0.001 | 27.5 (3.2) | 27.8 (3.1) | 27.7 (3.2) | 0.034 | 28.0 (3.2) | 27.9 (3.1) | 27.6 (3.1) | <0.001 |
| Prepregnancy BMI, kg/m$^2$ | 17.5 (0.8) | 21.1 (1.5) | 25.6 (1.1) | 30.4 (2.4) | <0.001 | 21.5 (3.5) | 21.0 (3.4) | 22.3 (3.3) | <0.001 | 21.4 (3.3) | 21.0 (3.2) | 22.3 (3.3) | <0.001 |
| Gestational age at delivery, wk | 39.2 (1.2) | 39.2 (1.3) | 39.2 (1.3) | 39.1 (1.3) | 0.015 | 39.3 (1.3) | 39.2 (1.3) | 39.1 (1.3) | <0.001 | 39.2 (1.2) | 39.2 (1.3) | 39.2 (1.3) | 0.135 |
| Caesarean delivery, % | 55.9 | 62.8 | 75.5 | 85.9 | <0.001 | 60.3 | 59.5 | 67.6 | <0.001 | 61.2 | 60.4 | 67.1 | <0.001 |
| Blood pressure at 2$^{nd}$ trimester, mmHg | | | | | | | | | | | | | |
| Systolic | 103 (9.7) | 106 (9.9) | 110 (10.1) | 114 (10.9) | <0.001 | 105 (10.1) | 105 (10.1) | 108 (10.3) | <0.001 | 106 (10.3) | 106 (10.4) | 107 (10.3) | <0.001 |
| Diastolic | 66 (6.8) | 68 (7.1) | 71 (7.5) | 73 (7.9) | <0.001 | 67 (7.2) | 67 (7.4) | 69 (7.3) | <0.001 | 68 (7.2) | 68 (7.4) | 68 (7.4) | <0.001 |
| Blood pressure at 3$^{rd}$ trimester, mmHg | | | | | | | | | | | | | |
| Systolic | 105 (9.9) | 108 (10.2) | 112 (10.5) | 115 (11.1) | <0.001 | 106 (10.3) | 107 (10.6) | 109 (10.5) | <0.001 | 106 (10.0) | 106 (10.1) | 109 (10.6) | <0.001 |
| Diastolic | 67 (7.1) | 69 (7.3) | 72 (7.7) | 75 (8.4) | <0.001 | 68 (7.4) | 69 (7.6) | 70 (7.6) | <0.001 | 68 (7.4) | 68 (7.3) | 70 (7.7) | <0.001 |
| Education, % | | | | | <0.001 | | | | 0.188 | | | | 0.190 |
| University and above | 45.6 | 48.9 | 40.8 | 32.7 | | 45.5 | 48.3 | 45.9 | | 46.7 | 48.4 | 45.7 | |
| Junior college | 27.0 | 26.7 | 28.3 | 27.8 | | 26.6 | 25.4 | 27.4 | | 26.8 | 27.1 | 27.1 | |
| High school and under | 27.4 | 24.4 | 30.9 | 39.5 | | 27.9 | 26.3 | 26.7 | | 26.5 | 24.5 | 27.2 | |
| Family income, yuan/ month, % | | | | | <0.001 | | | | 0.212 | | | | 0.188 |
| ≥3000 | 55.9 | 58.0 | 51.4 | 46.4 | | 54.7 | 56.6 | 56.0 | | 55.1 | 56.5 | 56.0 | |
| 2000–2999 | 23.0 | 21.5 | 25.5 | 24.2 | | 23.2 | 20.9 | 22.8 | | 23.9 | 23.6 | 22.2 | |
| <2000 | 21.1 | 20.5 | 23.1 | 29.4 | | 22.1 | 22.5 | 21.2 | | 21.0 | 19.9 | 21.8 | |
| Smoking during pregnancy, % | 1.4 | 0.9 | 1.5 | 1.7 | 0.009 | 1.0 | 1.0 | 1.2 | 0.666 | 1.5 | 0.9 | 1.1 | 0.200 |
| Passive smoking, % | 47.3 | 49.5 | 50.4 | 53.8 | 0.011 | 48.3 | 47.1 | 50.3 | 0.010 | 48.6 | 48.3 | 50.0 | 0.244 |