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Gestational Weight Gain Trend and Population Attributable Risks of Adverse Fetal Growth Outcomes in Ohio

Aimin Chen^a, Fan Xu^a, Changchun Xie^a, Tianying Wu^a, Ann M Vuong^a, Maohua Miao^b, Wei Yuan^b, and Emily A. DeFranco^c

^aDivision of Epidemiology, Department of Environmental Health, University of Cincinnati College of Medicine, Cincinnati, OH

^bDepartment of Epidemiology and Social Science on Reproductive Health, Shanghai Institute of Planned Parenthood Research, Shanghai, China

^cDivision of Maternal-Fetal Medicine, Department of Obstetrics and Gynecology, University of Cincinnati College of Medicine and Perinatal Institute, Cincinnati Children's Hospital Medical Center, Cincinnati, OH

Abstract

Background—The trend of gestational weight gain (GWG) in relation to the Institute of Medicine (IOM) guidelines and population attributable risks (PARs) of GWG on fetal growth outcomes remain unclear.

Methods—We analyzed Ohio birth certificates from 2006 to 2012 to examine GWG trend by prepregnancy body mass index, to calculate the risk of small- and large-for-gestational-age (SGA and LGA), and macrosomia (birthweight >4000 g or >4500 g) infants, and to estimate the PARs of GWG below or above the guidelines.

Results—Of 869,531 women who delivered singleton live births at 22–44 weeks of gestation, 4.5% were underweight, 48.9% were normal weight, 23.9% were overweight, and 22.7% were obese before pregnancy. About 36.5% of underweight, 52.6% of normal weight, 72.5% of overweight, and 62.4% of obese women gained weight above the guidelines, with only slight changes from 2006 to 2012. Also, 34.9% of underweight, 20.1% of normal weight, 16.3% of overweight, and 27.0% of obese women gained weight below the guidelines. The PAR of GWG below or above the guidelines was –13% for SGA, 32.6% for LGA, 28.1% for macrosomia >4000 g, and 48.3% for macrosomia >4500 g, mostly driven by currently GWG above the guidelines in normal weight, overweight, and obese women.

Conclusions—A high percentage of pregnant women gained weight outside of the current IOM GWG guidelines; however, changes from 2006 to 2012 were small. GWG above the IOM guidelines significantly contributed to a large proportion of LGA and macrosomic infants in the general population.

Keywords

Body mass index; gestational weight gain; large for gestational age; small for gestational age; macrosomia

The Institute of Medicine (IOM) 2009 gestational weight gain (GWG) guidelines recommended GWG based on maternal prepregnancy body mass index (BMI).¹ The trend of GWG by BMI in statewide or nationwide data has not been available, particularly after 2009, although GWG trend from 2000–2009 in the Pregnancy Risk Assessment Monitoring System has been reported.² Categorization of GWG within or outside of the BMI-specific guidelines by total GWG only without consideration of gestational age may induce bias for pregnancies shorter or longer than 40 weeks, thus weekly GWG in the 2nd and 3rd trimesters needs to be factored into the determination.³ GWG below the guidelines has been associated with small for gestational-age (SGA), while GWG above the guidelines has been linked to large-for-gestational-age (LGA) and macrosomia.^{4, 5} However, it is unclear how much GWG outside of the guidelines contributes to adverse fetal growth outcomes at the population level. We analyzed Ohio birth certificate data to determine: (i) GWG trend in relation to IOM 2009 guidelines; and (ii) the population attributable risks (PARs) of BMI and GWG categories on adverse fetal growth outcomes.

Methods

We obtained 2006–2012 de-identified birth certificate data from the Ohio Department of Health (ODH). From a total of 1,031,259 live birth records, we restricted to 869,531 (84.3%) singleton live births at 22–44 weeks of gestation, with maternal BMI 15–50 kg/m², GWG –30 to 80 lbs (–13.6 to 36.3 kg), and birthweight 350–6000 g. The study was approved by the Institution Review Boards (IRBs) at the ODH and the University of Cincinnati.

Maternal BMI (kg/m²) was calculated as the self-reported maternal prepregnancy weight (kg) divided by the square of maternal height (m). It was categorized as underweight (<18.5 kg/m²), normal weight (18.5–24.9 kg/m²), overweight (25–29.9 kg/m²), or obesity (≥30 kg/m²). Maternal total GWG (kg) was calculated as the maternal weight at delivery minus the prepregnancy weight reported on the birth certificate. The rate of weight gain in the 2nd and 3rd trimesters was calculated as (total GWG – 1st trimester weight gain [i.e., 2 kg for non-obese women and 1.5 kg for obese women])/(gestational age at delivery in weeks – 13).³

The rate of GWG below or above the recommended ranges was categorized as below or above the IOM GWG guidelines for the 2nd and 3rd trimesters: underweight women 0.44–0.58 kg/wk, normal weight women 0.35–0.50 kg/wk, overweight women 0.23–0.33 kg/wk, obese women 0.17–0.27 kg/wk.³

SGA and LGA was defined as birthweight <10th or >90th percentile of a sex- and gestational-age-specific birthweight reference in the US, respectively.⁶ We used two definitions for macrosomia, as birthweight >4000 g or >4500 g, to capture a moderate or a more severe phenotype in high birthweight.

We examined the percentages of pregnant women below, within, or above the GWG guidelines. We compared the data from all 7 years (2006 to 2012) and then by each year to examine the temporal trend of GWG. We determined risk ratios (RRs) and 95% confidence intervals (CIs) for fetal growth outcomes by maternal BMI and GWG (a total of 12 combinations) using Generalized Linear Models. We used normal weight women with GWG within the guideline as the reference. We adjusted for maternal age, race, education, marital status, enrollment in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), Kotelchuck's adequacy of prenatal care utilization (APNCU) index,⁷ and 2013 census-based National Center for Health Statistics Urban-Rural Classification Scheme for Counties,⁸ smoking during pregnancy, live birth order, sex of infant, and year of birth based on their associations with maternal BMI, GWG, and birth outcomes observed in this study and in the literature.^{4, 5}

We computed two PARs based on different scenarios assuming the associations between BMI and GWG and adverse fetal growth outcomes are causal.^{9, 10} The PAR1 estimated the contributions of both BMI and GWG, i.e. the percentage of the current incidence of adverse fetal growth outcomes that could be reduced if all women had a normal BMI and GWG within the IOM 2009 guideline. The PAR2 only estimated the contribution of GWG on these birth outcomes without alteration of BMI groups, i.e. the percentage of the current incidence of adverse fetal growth outcomes that could be reduced if women remained in their original BMI groups, but had GWG within the guidelines. We also calculated partial PARs of modifiable factors (BMI and GWG for PAR1 and GWG for PAR2) by holding non-modifiable factors (covariates) unchanged.¹¹

Results

Of 869,531 pregnancies, 4.5% of pregnant women were underweight prior to pregnancy, 48.9% were normal weight, 23.9% were overweight, and 22.7% were obese. Only 20.0% of women had GWG within the IOM 2009 guidelines, 21.4% had GWG below the guidelines, and 58.8% had GWG above the guidelines.

The GWG trend by BMI groups is shown in Figure 1. More than 50% of normal weight, 70% of overweight and 60% of obese women gained weight above the IOM 2009 guidelines during pregnancy, with only slight change in proportions from 2006 to 2012.

The proportion of SGA, LGA, macrosomia >4000 g, and macrosomia >4500 g was 10.3%, 7.4%, 8.1%, and 1.0%, respectively. Compared with normal weight women with GWG within the guideline, higher risk of SGA was observed in underweight, normal weight, and overweight women with GWG below the guidelines as well as underweight women with GWG within the guideline (Table 1). Higher risks of LGA and macrosomia were shown in underweight and normal weight women with GWG above the guidelines as well as overweight and obese women irrespective of GWG.

Table 2 shows the PARs in each of the 12 BMI and GWG categories as well as the total PARs. For SGA, the proportion would have increased by 21% if all women had a normal BMI and GWG within the guidelines. This increase would be slightly lower (13%) had they

remained in their BMI group, but had GWG within the guideline. The increases in both scenarios were driven by normal weight, overweight, and obese women had they reduced their GWG to meet the guidelines. If all women had a normal BMI and GWG within the guideline, the proportions of LGA, macrosomia >4000 g, and macrosomia >4500 g would decrease by 51.3%, 45.5%, and 67.9%, respectively. Alternatively, if they retained their BMI weight group status but had GWG within the guidelines, the proportions would be reduced by 32.6%, 28.1%, and 48.3%, respectively. These patterns were primarily driven by normal weight, overweight, and obese women who currently had GWG above the guideline had they reduced their GWG to the recommended level. The partial PARs, appended at the bottom line of Table 2, were similar to total PARs in values and interpretation.

Comment

This study investigates the trend of GWG in relation to the IOM 2009 guidelines at the population level and determines PARs of GWG below or above the guidelines on adverse fetal growth outcomes. Over half of pregnant women in Ohio had GWG above the guidelines, with only slight changes over 7 years. Had the women in each BMI category gained weight according to the GWG guidelines, the percentage of LGA and macrosomic infants would have decreased remarkably while the percentage of SGA infants would have increased slightly.

High proportions of overweight and obese women exceeded GWG guidelines, corroborating data from Pregnancy Risk Assessment Monitoring System (2000–2009), Florida statewide birth registry (2004–2007) and 16 tertiary care centers in the US (2003–2008).^{2, 4, 5} Long-term changes in GWG patterns would require more time following IOM's issuance of guidelines; however, raising awareness among expecting mothers and obstetric care providers is critical to yield substantial changes. In 2013, the IOM and American College of Obstetrics and Gynecology support the dissemination of the GWG guidelines and implementation at the practitioner level, and it is anticipated that GWG goal setting and nutrition and exercise consultation by practitioners will help gradually reduce GWG among overweight and obese women in the next few years.^{12, 13}

Normal weight, overweight, and obese women with GWG above the guidelines are most influential on the PARs of SGA, LGA, and macrosomia, partly due to their large proportion in population (57.2%). Encouraging these women to achieve GWG within the IOM guidelines is the key to reducing the risk of LGA and macrosomia. Nevertheless, the calculation of PAR hinges on the assumption of causality. Although various studies have reported the associations between excessive weight gain and LGA and macrosomia, it could be that accelerated fetal growth contributes to excessive weight gain. However, maternal extracellular fluid retention, body fat deposition, and other physiological changes during pregnancy contributed significantly to GWG in addition to fetal, placenta, and amniotic fluid. The combined role of prepregnancy BMI and GWG on fetal growth is likely to be influential.¹

The dataset is only from a single state and the need to evaluate at the national level is clear. The BMI was self-reported, and the GWG was derived from the birth certificate, therefore,

misclassification is a concern.^{14, 15} The impact of misclassification of BMI and GWG categories needs to be examined in future studies with validated measurements.

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Figure 1. Percentages of pregnant women with GWG below, within, or above the IOM 2009 guidelines by maternal prepregnancy BMI in Ohio during 2006–2012

Table 1

Adjusted risk ratios (RR) ^a and 95% confidence intervals (CIs) of fetal growth outcomes by maternal prepregnancy BMI and GWG categories

Maternal BMI (kg/m ²)	GWG in relation to guidelines	n	SGA		LGA		macrosomia >4000 g		macrosomia >4500 g	
			%	RR (95% CI)	%	RR (95% CI)	%	RR (95% CI)	%	RR (95% CI)
15.0–18.4	Below	13,744	27.9	2.47 (2.36, 2.58)	0.9	0.29 (0.25, 0.35)	1.1	0.30 (0.25, 0.35)	0.1	0.21 (0.10, 0.45)
	Within	11,276	18.3	1.41 (1.34, 1.49)	1.7	0.56 (0.48, 0.65)	2.2	0.57 (0.50, 0.65)	0.1	0.50 (0.29, 0.85)
	Above	14,371	12.4	0.82 (0.77, 0.86)	4.0	1.39 (1.28, 1.52)	4.6	1.30 (1.19, 1.41)	0.4	1.69 (1.27, 2.24)
18.5–24.9	Below	85,290	18.3	1.54 (1.50, 1.58)	2.4	0.69 (0.65, 0.73)	2.9	0.69 (0.66, 0.73)	0.2	0.66 (0.55, 0.80)
	Within	116,244	11.5	Reference	3.8	Reference	4.7	Reference	0.3	Reference
25.0–29.9	Above	223,587	7.8	0.62 (0.60, 0.63)	7.9	2.15 (2.08, 2.22)	8.8	1.95 (1.89, 2.01)	1.0	2.98 (2.67, 3.33)
	Below	33,779	14.4	1.10 (1.06, 1.14)	3.7	1.09 (1.02, 1.16)	4.2	1.03 (0.97, 1.10)	0.4	1.21 (0.98, 1.51)
	Within	23,495	11.2	0.93 (0.89, 0.98)	5.5	1.50 (1.41, 1.60)	6.3	1.43 (1.35, 1.51)	0.6	1.72 (1.41, 2.11)
	Above	150,583	7.5	0.58 (0.57, 0.60)	10.2	2.77 (2.68, 2.87)	11.0	2.44 (2.36, 2.51)	1.5	4.39 (3.93, 4.91)
30.0–50.0	Below	53,266	11.1	0.85 (0.82, 0.88)	7.3	2.09 (2.01, 2.19)	7.4	1.79 (1.72, 1.87)	1.0	3.12 (2.73, 3.58)
	Within	20,907	8.8	0.70 (0.66, 0.74)	9.0	2.39 (2.26, 2.52)	9.5	2.14 (2.03, 2.25)	1.2	3.42 (2.90, 4.04)
	Above	122,989	7.2	0.52 (0.51, 0.54)	13.1	3.67 (3.55, 3.79)	13.3	3.07 (2.98, 3.16)	2.2	6.99 (6.27, 7.80)

^a Adjusted for maternal age, race, education, marital status, WIC, prenatal care adequacy, urbanicity, smoking, live birth order, sex of infant, year of birth

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Table 2

Population attributable risks^a of maternal prepregnancy BMI and GWG categories for fetal growth outcomes

Maternal BMI (kg/m ²)	GWG in relation to guidelines	<i>i</i>	Probability in population (P _{<i>i</i>})	SGA		LGA		macrosomia >4000 g		macrosomia >4500 g	
				PAR _{<i>i</i>}	RR _{<i>i</i>}	PAR _{<i>i</i>}	RR _{<i>i</i>}	PAR _{<i>i</i>}	RR _{<i>i</i>}	PAR _{<i>i</i>}	PAR _{<i>i</i>}
15.0– 18.4	Below	1	0.0158	2.47	2.0	0.29	−0.2	0.30	−0.2	0.21	−0.4
	Within	2	0.0130	1.41	0.0	0.56	0.0	0.57	0.0	0.50	−0.2
	Above	3	0.0165	0.82	−1.2	1.39	0.7	1.30	0.7	1.69	0.4
18.5– 24.9	Below	4	0.0981	1.54	6.4	0.69	−1.5	0.69	−1.7	0.66	−1.1
	Within	5	0.1337	1.00	0.0	1.00	0.0	1.00	0.0	1.00	0.0
	Above	6	0.2571	0.62	−11.8	2.15	15.0	1.95	14.0	2.98	16.3
25.0– 29.9	Below	7	0.0388	1.10	0.5	1.09	0.2	1.03	−0.9	1.21	0.3
	Within	8	0.0270	0.93	−0.2	1.50	0.7	1.43	0.0	1.72	0.6
	Above	9	0.1732	0.58	−8.8	2.77	11.2	2.44	10.0	4.39	18.8
30.0– 50.0	Below	10	0.0613	0.85	−1.1	2.09	−0.9	1.79	−1.2	3.12	4.2
	Within	11	0.0240	0.70	−0.9	2.39	0.0	2.14	0.0	3.42	1.9
	Above	12	0.1414	0.52	−8.2	3.67	9.2	3.07	7.5	6.99	27.2
Total PARs				−21.0	−13.0	51.3	32.6	45.5	28.1	67.9	48.3
Partial PARs and 95% CIs				−18.0 (−21.1, −14.8)	−10.7 (−12.4, −8.9)	55.0 (53.4, 56.6)	36.9 (35.5, 38.4)	48.8 (47.0, 50.4)	32.5 (31.0, 33.9)	68.4 (64.9, 71.7)	48.2 (44.5, 51.7)

$${}^a PAR_{1_i} \% = 100 \times P_i \times (RR_i - 1) / (1 + \sum_1^{12} P_i \times (RR_i - 1)), \text{ and } PAR1 \% = \sum_1^2 PAR_{1_i} \%$$
$$PAR_{2_i} \% = 100 \times P_i \times (RR_i - RR_{\text{within guideline} | BMI \text{ group}}) / (1 + \sum_1^{12} P_i \times (RR_i - 1)), \text{ and } PAR2 \% = \sum_1^{12} PAR_{2_i} \%$$