Maternal gestational weight gain and offspring's weight at 1 year of age in rural Guangxi province, China: the mediating role of birth weight

Olubunmi Orekoya [1], Jihong Liu [1], Sarah Rothenberg[1], Nansi Boghossian[1], Linda Hazlett[1], Bo Cai[1]

[1] Arnold School of Public Health, University of South Carolina

Introduction

- Early life exposures such as maternal gestational weight gain (GWG) and suboptimal nutrition have significant implications for weight gain and contributes to morbidity among offspring. [1,2]
- Excessive GWG in mothers is a public health problem in developed countries. Yet little is known about maternal GWG and its association with offspring's weight in China and other developing countries.

Objective

- To evaluate the association between maternal GWG and offspring weight at 1 year in rural China and to examine the mediating role of birthweight in this relationship.

Methods

- Data came from a recent (2013-2014) prospective study of 398 pregnant women and their offspring living in rural Guangxi province of China, a border town near Vietnam.
- 316 women completed both the baseline visit (at parturition) and the follow-up visit with their child at 1 year after delivery.

Exposure and Outcome assessment

- ***Exposure:*** Total gestational weight gain was calculated as the difference between the mother's weight at delivery and her prepregnancy weight.
- GWG was further categorized into inadequate, adequate, and excessive weight gain, according to the 2009 Institute of Medicine (IOM) guidelines[4] and using Chinese BMI categories cut-off points (See Table 1).[1,3]
- ***Outcome:*** Offspring measured weight and height at 1 year were used to calculate weight for age Z scores (WAZ) using the WHO gender- and age-specific standards.

Potential Confounders

- Maternal age, ethnicity, prepregnancy BMI, occupation, education, second-hand smoking, pregnancy complication, and infant's gender and gestational age at birth

Mediator:

- Birth weight adjusted for gestational age using the 21st INTERGROWTH Standards, which includes data from China and other developing countries. [5]

Statistical Analyses

- Multivariate analyses using generalized linear models were conducted to obtain β estimates and p-values while adjusting for potential confounders.
- Mediation analysis: Vanderweele's SAS macro was used to decompose the total effects of GWG into direct and indirect effects via birthweight.[6]

Results

- Mean total maternal GWG was 11.7kg (±5.1).
- Mean gestational age at delivery was 39.1 weeks (±1.2), ranging between 34.9 and 42.0 weeks, 7 women had preterm birth (< 37 weeks).
- Based on the IOM's guidelines for maternal GWG, gaining inadequate weight during pregnancy (51.1%) was more prevalent than gaining excessive (20.0%) or adequate (28.9%) weight.
- At 1 year of age, 23.2% of infants' weight-for-age percentile were below the 10th percentile according to the WHO growth standards, while 73% and 3.8% were normal weight (10^{th}-85^{th} percentile) and overweight (>85^{th} percentile), respectively.
- After adjusting for confounders, total GWG was positively associated with weight-for-age Z-scores (WAZ) (β=0.02; p=0.042), i.e. for every one kg increase in GWG, WAZ increased by 0.02 (Table 2).
- Offspring of mothers with inadequate GWG had a lower WAZ score when compared with offspring of mothers with adequate GWG at borderline significance (β = -0.20; p=0.079). However, there was no significant difference in WAZ score between offspring of mothers with excessive GWG and women with adequate GWG (Table 2).
- Mediation analysis showed significant indirect effect of GWG via birthweight on WAZ (Table 3). However, the direct effect of GWG on WAZ was not significant.
- Mean WAZ for infants born to farmers (β=-0.21; p=0.04) or Zhuang ethnicity (β =-0.28; p=0.04) were significantly lower when compared to non-farmers or Han and other ethnicities, respectively.

Table 1: Descriptive Sample Characteristics of Study Participants by Gestational Weight Gain (GWG) Categories (n=315)

Variable	Inadequate	Adequate	Excessive	P value [a]
Total, No. (%)	161 (51.11)	91 (28.89)	63 (20)	
Mother's Age (years), No. (%)				0.352
<25 years	50 (31.06)	30 (32.97)	22 (34.92)	
25-35 years	82 (50.93)	53 (58.24)	33 (52.38)	
≥35years	29 (18.01)	8 (8.79)	8 (12.70)	
Prepregnancy BMI (kg/m^2), No. (%)				0.002
Underweight (<18.5)	46 (28.57)	23 (25.27)	11 (19.05)	
Normal (≥ 18.5 and ≤ 23.9)	107 (66.46)	55 (66.44)	36 (57.14)	
Overweight (≥24 and ≤ 27.9)	8 (4.97)	10 (10.99)	12 (19.05)	
Obese (≥28)	0 (0.00)	3 (3.30)	3 (4.76)	
Race/ethnicity, No. (%)				0.934
Zhuang	142 (88.20)	78 (85.71)	56 (88.89)	
Han	16 (9.94)	10 (10.99)	6 (9.52)	
Others	3 (1.86)	3 (3.30)	1 (1.59)	
Occupation, No. (%)				0.452
Farmers	123 (77.36)	64 (72.73)	42 (66.67)	
Non-farmers	11 (6.92)	9 (10.23)	10 (15.87)	
Unemployed	20 (12.58)	10 (11.36)	8 (12.70)	
Others	5 (3.14)	5 (5.68)	3 (4.76)	
Maternal Education level, No. (%)				0.042
< High School	136 (85.00)	72 (80.00)	44 (72.13)	
High school	17 (10.63)	14 (15.73)	11 (18.03)	
University	7 (4.38)	3 (3.37)	6 (9.84)	
Second-hand smoking, No. (%)				0.095
Yes	58 (37.18)	37 (41.97)	33 (53.23)	
No	98 (62.82)	52 (58.43)	29 (46.77)	
Baby's gender, No. (%)				0.885
Male	80 (49.69)	47 (51.65)	30 (47.62)	
Female	81 (50.31)	44 (48.35)	33 (52.38)	
Birth weight (grams), mean (SE)	3012.11 (363.65)	3188.46 (436.02)	3286.51 (356.65)	0.001
Total GWG (kg) , mean (SE)	8.20 (2.96)	13.14 (2.45)	18.75 (3.65)	0.001
Complication in pregnancy, No.(%)				0.646
Yes	11 (6.96)	4 (4.49)	5 (7.94)	
No	147 (93.04)	85 (95.51)	58 (92.06)	
Weight for age percentile at age 1, No. (%)				0.007
<10^{th} percentile	40 (24.84)	23 (25.27)	10 (15.87)	
10^{th} - 85^{th} percentile	120 (74.53)	60 (65.93)	50 (79.37)	
≥ 85^{th} percentile	1 (0.62)	8 (8.79)	3 (4.76)	

a P < 0.05 for group comparison using Chi-square test of independence (fishers test for small sample)
Frequency missing: second-hand smoking (n=8); maternal education(n= 5); pregnancy complication (n=5)

Table 2: Association between maternal gestational weight gain and weight for age Z-scores

	Crude Model		Adjusted model	
	β	P-value	β	P -value
Total gestational weight gain	0.02	**0.036**	0.02	**0.042**
Adequacy of gestational weight gain				
Inadequate	-0.18	0.095	-0.20	0.079
Excessive	0.16	0.257	0.11	0.408
Adequate	Reference		Reference	

Adjusted Model : Adjusted for maternal age, maternal prepregnancy BMI, ethnicity, occupation, pregnancy complication, and offspring's gender

Table3: Direct and indirect effects of the association between GWG and weight for age Z scores at 12 months mediated through birthweight adjusted for-gestational age

	Weight for age Z scores						
Gestational weight gain measures	Natural direct effect		Natural Indirect effect		Total Effect		% mediated through birth weight
	β (95% CI)	P-value	B (95% CI)	P-value	B (95% CI)	P-value	
Total weight gain	0.05(-0.07,0.16)	0.413	0.07 (0.03, 0.12)	**0.001**	0.12 (0.00,0.23)	**0.036**	58.33
Adequacy of gestational weight gain							
Inadequate vs. adequate	0.10 (-0.31, 0.11)	0.300	-0.11 (-0.18,-0.03)	**0.004**	-0.21 (-0.42, 0.01)	0.060	52.38
Excessive vs. adequate	0.05 (-0.06, 0.16)	0.347	0.05 (0.02, 0.09)	**0.004**	0.11 (-0.00, 0.21)	0.057	45.45

Adjusted Model : Adjusted for maternal age, maternal prepregnancy BMI, ethnicity, occupation, pregnancy complication, and offspring's gender

Conclusion

- Maternal GWG was significantly associated with offspring's weight at 1 year of age.
- Birth weight is possibly a mediator between the association of maternal GWG and offspring's weight in infancy.
- Our results suggest that targeted nutrition programs should be designed to help pregnant women gain healthy weight during pregnancy and assist healthy growth of infants living in rural areas.

Strengths and Limitations

Strengths:

- Use of a recent prospective data
- Geographic location being the rural part of southern China, population characteristics with the majority being farmers, and of low socioeconomic status – help us to contribute to the limited knowledge of MCH among this target group
- Utilization of mediation analysis

Limitations:

- Relatively small sample size

Acknowledgements

- The authors thank the U.S. National Institute of Environmental Health Sciences (R15 ES 022409) and the U.S. National Institutes of Health Loan Replacement Program (L30 ES023165), who provided grant supports to S. E. Rothernberg
- The authors also acknowledge support to Olubunmi Orekoya from the Seung Yeun Kim Dissertation Award at the Walker Institute, the University of South Carolina

References

1. Li N, Liu E, Guo J, et al. Maternal prepregnancy body mass index and gestational weight gain on offspring overweight in early infancy. *PLoS One*. 2013;8(10).
2. Li N, Liu E, Guo J, et al. Maternal prepregnancy body mass index and gestational weight gain on pregnancy outcomes. *PLoS One.* 2013;8(12).
3. Working Group on Obesity in China (2004) Guidelines for Prevention and Control of Overweight and Obesity in Chinese Adults. *Acta Nutrimenta* Sin 26: 1-4
4. Institute of Medicine (US) and National Research Council (US) Committee to Reexamine IOM Pregnancy Weight Guidelines. Weight Gain During Preganncy: Reexamining the Guidelines: Washington (DC): National Academies Press (US); 2009.
5. Valeri L, Vanderweele TJ. Mediation analysis allowing for exposure-mediator interactions and causal interpretation: theoretical assumptions and implementation with SAS and SPSS macros. *Psychol Methods.* 2013;18(2):137-150.
6. J, V., G, A. D., M, P., A, N. J., E, K. H., P, R., Cheikh, I. L., C, B. F., A, L., T, P. A., M, C., A, J. Y., E, B., G, G. M., A, B. Z., H, K. S. (2013). The objectives, design and implementation of the INTERGROWTH-21st Project. *BJOG*, *120*(Suppl. 2), 9-26.