Infant Growth following Maternal Participation in a Gestational Weight Management Intervention

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Abstract

Background: Obesity is widespread and treatment strategies have demonstrated limited success. Changes to obstetrical practice in response to obesity may support obesity prevention by influencing offspring growth trajectories.

Methods: This retrospective cohort study examined growth among infants born to obese mothers who participated in Nutrition in Pregnancy (NIP), a prenatal nutrition intervention at one urban hospital. NIP participants had Medicaid insurance and BMIs of 30 kg/m² or greater. We compared NIP infant growth to a historical control cohort, matched on maternal factors: age, race/ethnicity, prepregnancy BMI, parity, and history of prepregnancy hypertension or preterm birth.

Results: Growth data were available for 61 NIP and 145 control infants. Most mothers were African American (94%). Mean maternal BMI was 39.9 kg/m² (standard deviation [SD], 5.6) for NIP participants and 38.8 kg/m² (SD, 6.0) for controls. Pregnancy outcomes, including preterm birth, gestational diabetes, and birth weight, did not differ between groups. NIP participants were more likely to attend a postpartum visit (69% vs. 52%; *p* value, 0.03). At 1 year, 17% of NIP infants and 15% of controls had weight-for-length (WFL) ≥95th percentile (*p* value, 0.66). Other markers of accelerated infant growth, including crossing WFL percentiles and peak infant BMI, did not differ between groups.

Conclusions: There was no difference in growth between infants whose mothers participated in a prenatal nutrition intervention and those whose mothers did not. Existing prenatal programs for obese women may be inadequate to prevent pediatric obesity without pediatric collaboration to promote family-centered support beyond pregnancy.

Introduction

Pediatric obesity is difficult to reverse^{1–3} and currently has a prevalence of 17% in the United States.⁴ Prevention is therefore critical to promoting long-term health, particularly among those at high risk for obesity. Maternal obesity is a known risk factor for development of obesity among children.^{5,6} Currently, close to one third of women becoming pregnant in the United States are obese.^{4,7,8}

Because pediatric obesity develops early in life, obesity prevention starting in the prenatal period is theoretically promising.⁹ Life course science describes the importance of discrete developmental periods that influence health far into the future. The prenatal period is recognized as a critical period for physiological development, when bio-

logical embedding can be protective or harmful for lifelong health.^{10,11} In addition, pregnancy is an important period for health behavior change. Successful behavior change during pregnancy has been attributed to increased contact with the healthcare system and increased motivation to change.^{12,13}

Obesity during pregnancy increases medical risks for women including increased rates of intrauterine fetal death, pre-eclampsia, and cesarean delivery.¹⁴ In 2009, the Institute of Medicine (IOM) issued new guidelines addressing appropriate gestational weight gain (GWG).¹⁵ However, only around 30% of women are meeting the recommended GWG targets.¹⁶ Obstetrical practice is changing to address these guidelines, and data suggest that meeting IOM guidelines does improve pregnancy outcomes.^{16–19} Changes in obstetrical practice may also

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influence offspring growth patterns. However the influence of obstetrical changes on pediatric outcomes remains largely unexamined.

This project assessed one obstetrical clinic's response to increased obesity in their patient population. This clinic's novel obstetrical model aims to limit GWG, but also addresses behaviors relevant to infant feeding, such as portion size and consumption of sugar-sweetened beverages. This clinic is of interest because it represents an early innovation in response to obstetrical obesity, targets a high-risk population of low-income, urban women in the United States, and represents a potentially reproducible clinical model because it does not rely on external grants. Drawing on past work linking infant growth profiles to childhood obesity, we assess whether infants born to mothers who participated in this program demonstrated different growth trends during infancy compared to infants born before the initiation of this program.

Methods

Setting

The Nutrition in Pregnancy clinic (NIP) was established in late 2011 at Johns Hopkins Hospital (Baltimore, MD), an urban tertiary care referral center. Women with Medicaid insurance who have a prepregnancy BMI of 30 kg/m² or greater are automatically referred to NIP, but may opt to receive care outside of NIP if they have a conflict with the clinic time or prefer a non-NIP clinician. Women with pre-existing diabetes, heart disease, systemic lupus erythematosus, and women carrying multiple gestations are excluded from NIP and followed in the traditional high-risk obstetrical clinic.

Women attending the NIP clinic are offered visits every other week until 36 weeks gestation and then weekly visits until delivery. NIP integrates obstetrical and nutritional care by providing time at each visit for women to meet with both the obstetrician or nurse practitioner and the nutritionist. All visits are individual visits. Initial visits are scheduled for 30 minutes of physician or nurse practitioner time and subsequent visits for 15 minutes. Participants also meet with a nutritionist at each visit. The clinic operates 1 day per week at the same location as non-NIP obstetrical care. NIP is primarily staffed by one obstetrician, one nurse practitioner, one nutritionist, and one social worker. Obstetrical residents rotate through the clinic. Screening and referral for mental health concerns is also a focus of the clinic.

The nutritionist in the clinic provides general education on topics including portion sizes, decreasing consumption of carry-out, fried foods, and sugar-sweetened beverages, and meal planning and grocery shopping. Individualized assessment of dietary patterns is performed to identify targets for change.

This study was approved by the Johns Hopkins Medicine Institutional Review Board.

Cohort Selection

This is a retrospective cohort study. For this analysis, we considered NIP treatment to consist of presentation for prenatal care by 21 weeks gestation and at least one visit at NIP in each of the second and third trimesters. We identified 136 women who met these criteria and delivered live infants between clinic inception and April 1, 2014. Exclusion criteria included: inability to identify the infant medical record number from the mother's chart ($n=10$); infant with congenital anomalies leading to organ failure or surgery in the first months of life ($n=5$); or infant not receiving medical care in our system ($n=57$). This yielded 64 mother-infant dyads. We subsequently excluded three dyads with a maternal prepregnancy BMI of greater than 60 kg/m² because we were unable to find appropriate control matches.

The control cohort was drawn from women who delivered at our hospital between January 1, 2009 and December 31, 2011. This cohort consisted of women who would have been eligible for NIP, had it existed at the time. In other words, these women received prenatal care covered by public insurance, initiated prenatal care by 21 weeks gestation, and had BMIs ≥ 30 kg/m². Exclusion criteria were: mothers with pre-existing cardiac disease; pregestational diabetes mellitus; system lupus erythematosus; multiple gestations; or infant receiving pediatric care in another health system.

Our goal was to create a matched cohort with two control dyads for each treatment dyad. We attempted exact matching on BMI category (30–35, 35–40, 40–45, or >45 kg/m²), age (<20 , 20–24, 25–29, 30–34, 35–39, or >40 years), race/ethnicity (non-Hispanic Caucasian, non-Hispanic African American, or Hispanic, as self-reported and included in the electronic obstetrical record), parity (nulliparous vs. multiparous), pre-existing hypertension (HTN), and history of preterm birth. For individuals with characteristics that were less common in our clinical population (*e.g.*, Caucasian race, history of HTN or preterm birth, or BMI >40), we were unable to find exact matches and so proceeded with nearest neighbor matching, prioritizing history of pre-existing conditions and BMI category over other characteristics.

When multiple possible controls were available, we selected infants born at later dates (*i.e.*, closer to the initiation of NIP). Because of the small size of the cohort, matching was conducted manually and generated a control group of 145 women. Our control group is more than twice as large as our treatment group because exclusion of women with a BMI >60 kg/m² or initiation of prenatal care after 21 weeks gestation occurred after matching. This eliminated a disproportionate number of women from the treatment group, but improved comparability between groups on baseline measures.

Data Abstraction

Maternal data were drawn from the obstetrical electronic medical record. Race/ethnicity was self-reported. Maternal BMI represents measured height and prepregnancy weight

as reported at the first visit. We also had access to first recorded weight for the NIP cohort, and this correlated closely with reported prepregnancy weight (correlation coefficient, 0.98). We abstracted the following data from the obstetrical record: smoking status at first prenatal care; gestational diabetes; gestational weight gain; gestational age at birth; infant birth weight; and maternal attendance at the postpartum visit. The NIP model has not yet been evaluated for impact on obstetrical outcomes, and we considered these obstetrical outcomes to be important measures of the NIP process.

Infant growth data were taken from the outpatient electronic medical record. We abstracted weight, height, and age from well visits at nine possible time points up to 15 months of age. Analysis was conducted using Stata software (version 13.1; StataCorp LP, College Station, TX).²⁰ The user-written package “zanthro” was used to assign weight-for-age, BMI-for-age, and weight-for-length (WFL) percentiles.²¹

Outcomes and Analysis

Our primary outcome was WFL percentile at 1 year on the CDC 2000 growth curves. We also evaluated crossing WFL percentiles and maximum BMI in infancy. Both of these measures have been studied previously and have been associated with developing obesity at 5–10 years of age.^{22,23}

To assess crossing WFL percentiles, we followed the method used by Taveras and colleagues.²² In other words, we considered infants who crossed two major percentiles on the 2000 CDC growth curves within a 6-month window to be high risk for subsequent obesity. All NIP infants had weight and length data available within 1 month of birth, but only 32 had available growth data within 5–7 months of age and only 37 had growth data at both 5–7 months and 11–13 months.

Finally, we looked at peak BMI in infancy. Peak BMI of 17 kg/m^2 or greater has been associated with subsequent obesity in a retrospective case-control study.²³ These data were available for all infants.

In a post-hoc subgroup analysis, we assessed whether a dose response existed between the number of NIP visits and GWG or infant weight status at 1 year. This analysis used bivariate regression with the number of NIP visits as the independent variable.

Results

Groups were balanced on baseline maternal factors (Table 1). Most women were in their twenties, and almost all reported non-Hispanic African American race/ethnicity. Mean BMI was 39.9 kg/m^2 (standard deviation [SD], 5.6) for NIP and 38.8 kg/m^2 (SD, 6.0) for controls. We did not explicitly match on prenatal tobacco use, but groups were balanced on this measure as well (NIP, 13%; control, 10%).

NIP participants were more likely to attend a postpartum visit than control participants (NIP, 69%; control, 52%; p

value, 0.03). Aside from this, there were no statistically significant differences in pregnancy outcomes (Table 1). However, there were several differences in pregnancy outcomes that were potentially clinically meaningful, though not statistically significant. For example, 37% of the NIP participants met IOM guidelines for GWG, whereas only 28% of controls did (p value, 0.20). Similarly, 5% of NIP participants delivered a macrosomic infant, compared to 10% of controls (p value, 0.26), with no difference in low-birth-weight infants. In addition, 8% of NIP women delivered at <35 weeks gestation, compared to 4% of control women (p value, 0.24).

There were no differences in infant growth outcomes between the two groups (Table 2). Our primary outcome of WFL at 1 year was 67th percentile for NIP participants (SD, 29) and 62nd percentile for controls (SD, 30). WFL was ≥ 95 th percentile for 17% of NIP infants and 15% of controls. Of 37 NIP infants and 117 control infants with available data to assess crossing WFL percentiles between 1 and 6 months, 41% from both groups crossed ≥ 2 major percentiles. Of 32 NIP infants and 97 controls with adequate data to assess crossing WFL percentiles between 6 and 12 months, 31% of NIP infants crossed ≥ 2 major percentiles, as did 28% of control infants (p value, 0.71).

When looking at peak BMI in infancy, we found that 89% of NIP infants had a peak $>17 \text{ kg/m}^2$ (mean peak BMI 18.8 reached at a mean of 258 days). Similarly, 87% of control infants peaked at $>17 \text{ kg/m}^2$ (mean peak BMI 18.8 reached at a mean age of 256 days).

In post-hoc subgroup analysis, there was a nonsignificant association between increased number of NIP visits and lower GWG. In bivariate regression, each additional visit was associated with 0.5 pounds less weight gain during pregnancy (beta coefficient, -0.5 ; 95% confidence interval, -1.0 , 0.1 ; p value, 0.10). There was no evidence for a dose response between clinic visits and infant weight status at 1 year.

Discussion

There were no differences in infant growth between infants of obese mothers who participated in a prenatal nutrition program and infants of obese mothers who did not participate in this program. Mothers participating in NIP were more likely to attend a postpartum visit, which is a marker of high-quality prenatal care.²⁴ Although there were no statistically significant differences in pregnancy outcomes, the data suggest that NIP may improve GWG and appropriate birth weight.

Previous literature addressing obesity during pregnancy has shown improvements in pregnancy outcomes, but rarely reports on outcomes beyond the perinatal period. For example, a systematic review found that interventions to reduce or prevent obesity in pregnancy led to reduced preeclampsia, shoulder dystocia, and preterm birth.²⁵ A subsequent prenatal group-based dietary intervention in the United States resulted in fewer macrosomic births in the treatment arm compared to the control group.²⁶

Table 1. Baseline Features and Pregnancy Outcomes

	NIP cohort N = 61	Control cohort N = 145	p value*
	– n (%) or mean (SD) –		
Maternal factors			
Age (years)	26.1 (5.8)	25.9 (5.4)	0.86
Race			0.62
Non-Hispanic African American	56 (93%)	137 (95%)	
Non-Hispanic white	4 (7%)	6 (4%)	
Hispanic	0	1 (1%)	
Prepartum BMI (kg/m ²)	39.9 (5.6)	38.8 (6.0)	0.19
Pre-existing HTN	12 (20%)	26 (18%)	0.77
History of preterm birth	6 (10%)	10 (7%)	0.47
Multiparous	39 (65%)	93 (64%)	0.91
GA at first prenatal care (weeks)	12.3 (3.7)	12.3 (3.2)	0.97
Smoking at first prenatal care	8 (13%)	14 (10%)	0.46
Pregnancy outcomes			
Gestational diabetes	11 (18%)	15 (10%)	0.13
GWG (lbs)	19.3 (14.3)	18.9 (16.5)	0.86
GWG within IOM recs	22 (37%)	40 (28%)	0.20
Gestational age at birth (weeks)	38.3 (2.9)	38.9 (1.9)	0.18
Gestation age at birth <35 weeks	5 (8%)	6 (4%)	0.24
Birth weight (g)	3176 (655)	3193 (629)	0.86
Macrosomic (≥4000 g)	3 (5%)	14 (10%)	0.26
Low birth weight (<2500 g)	5 (8%)	14 (10%)	0.74
Attended postpartum visit	42 (69%)	76 (52%)	0.03

*p values represent results of t-tests for continuous variables and chi-squared tests for categorical variables.

HTN, hypertension; GA, gestational age; GWG, gestational weight gain; IOM recs, Institute of Medicine recommendations; SD, standard deviation.

Similar to our study, the few studies that have reported on infant growth after prenatal interventions have found no changes in infant growth. This includes two previous European studies with null results^{27,28} and one study in the United States evaluating a walking intervention during pregnancy that followed babies to 6 months postpartum.²⁹ Biological explanations for these null findings have been proposed. Prepregnancy BMI may irreversibly set placental metabolism at the start of pregnancy, such that subsequent interventions have limited impact on infant weight or metabolism.³⁰ However, there would still be potential for pregnancy-related behavioral modification within the family to continue postpartum and influence infant growth.

To our knowledge, our study is the first to present pediatric growth outcomes after a nutritional intervention for obese pregnant women in a low-income, US urban population. Though our findings may have limited generaliz-

ability beyond similar settings, we view the NIP patient population as a strength of this study. Currently, African American babies represent 15% of total births in the United States, but 28% of infant deaths.³¹ By adolescence, African American youth are 15% more likely than their white peers to be obese, and in adulthood they are 22% more likely to die from cardiovascular disease.^{4,32} Reversing these inequities requires specific attention to the population served by NIP. Based on race, income, and geographical residence, NIP participants represent a population that has experienced significant barriers to healthcare access,^{33,34} yet NIP has been feasible for both patients and clinical staff. The NIP model is of particular interest because it is funded exclusively through reimbursement from local Medicaid payors.

Despite the potential need for programs such as NIP, our findings show that this model alone is not adequate to improve offspring weight trajectories for infants of obese

Table 2. Infant Growth Outcomes

	NIP N	NIP cohort	Control N	Control	p value ^a
WFL at 1 year					
WFL %	59	0.67 (0.29)	145	0.62 (0.30)	0.36
WFL % ≥95th	59	10 (17%)	145	21 (15%)	0.66
Crossing WFL %					
1–6 months ^c	37		117		
Crossed ≥2 ^b		13 (41%)		41 (41%)	0.99
1-month WFL >90th		5 (14%)		16 (14%)	0.98
6–12 months	32		97		
Crossed ≥2 ^b		3 (14%)		14 (20%)	0.50
6-month WFL >90th		10 (31%)		27 (28%)	0.71
Maximum BMI					
BMI peak >17 kg/m ²	61	54 (89%)	145	126 (87%)	0.75
Maximum BMI	61	18.8 (1.6)	145	18.8 (1.8)	0.88

^ap values reflect results from t-tests for continuous variables and chi-squared tests for categorical variables.

^bIndividuals with WFL <90th percentile at start time for interval.

^cAccepts any measurement within 30 days of start and end time, consistent with Taveras and colleagues.²²

NIP, Nutrition in Pregnancy; WFL, weight-for-length.

mothers. We found that 17% of NIP infants have WFL ≥95th percentile at 1 year of age, consistent with offspring growth before NIP and more than double the most recent national estimates.⁴

More concerning is that NIP participation may adversely influence some pregnancy outcomes. For example, though our analysis did not demonstrate statistically significant differences in preterm birth, 8% of NIP infants were born at ≤35 weeks gestation. This was double the rate in our control cohort. We are not powered to detect a difference of this magnitude, but if this reflects a true difference, it would be clinically important. One explanation for this finding is that NIP participants may have received an increased frequency of care, compared to non-NIP participants, and this may lead to increased testing and diagnosis. Our data cannot address whether increased visits or testing did, in fact, occur nor whether increased intervention ultimately benefited the mother or infant. Future studies would benefit from data on rates of induced deliveries or other responses to abnormal testing.

NIP requires further development to achieve desired outcomes. The urgent need for obesity prevention argues that pediatricians should be actively involved in designing and developing obstetrical programs to address obesity. In order to play an effective role in obesity prevention, these programs may need to directly address infant feeding topics and link directly to ongoing prevention efforts in the pediatric setting.

Our study has several limitations. As noted, we were underpowered to detect cohort differences in obstetrical outcomes. We may also have been underpowered to detect

differences in infant growth, though our growth outcomes suggest that, even with a larger sample, clinically meaningful differences would not exist between groups. Our study addressed a single clinic serving low-income, African American, urban women, so findings may not be generalizable to other settings. In addition, changes in obstetrical care of obese women and increased social attention to the problem of obesity indicate that our historical control and treatment group may have differed in ways that are not solely attributable to NIP. Finally, though we tried to match on important baseline characteristics, there may have been unmeasured factors that differed between groups and influenced outcomes. In particular, NIP participants may represent a subset of pregnant women who are particularly interested in engaging with the healthcare system, a characteristic that we were not able to select for in our control group.

Conclusions

These findings provide early evidence about the impact of emerging obesity-related obstetrical programs on infant growth. Existing programs are theoretically promising, but may be inadequate to prevent pediatric obesity. Pediatric clinicians should be aware of emerging prenatal programs and partner with obstetrical colleagues in developing these programs. Specifically, clinicians should support a family-centered approach in prenatal programs and can provide expertise about important messages around infant feeding. In addition, effective services should be developed in the pediatric setting to promote sustained behavior change

among parents and initiation of healthy feeding practices for offspring.

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