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Association of Pre-Pregnancy BMI and Postpartum Weight Retention before Second Pregnancy, Washington State, 2003–2013

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Introduction

Maternal obesity is of growing concern in the United States. Obesity is the most common medical condition in women of reproductive age that impacts both the mother and her offspring,(Flegal, Carroll, Ogden, & Johnson, 2002) affecting approximately 38.3% of women of childbearing age according to a National Health and Nutrition Examination Survey (Flegal et al., 2002). A study by Heslehurst et al. showed that the rate of obesity among pregnant women has been slowly accelerating; (Heslehurst et al., 2007) overweight and obesity are of particular concern in this population given the increased risk posed for gestational diabetes mellitus, hypertensive disorders, induction of labor, prolonged duration of labor, post-term delivery, shoulder dystocia, increased blood loss, cesarean section rates, newborn macrosomia and newborn hospitalization among other perinatal complications (Catalano & Shankar, 2017; Usha Kiran, Hemmadi, Bethel, & Evans, 2005). Additionally, studies have demonstrated that maternal obesity is associated with a doubling of the risk of stillbirth and neonatal death, (Kristensen, Vestergaard, Wisborg, Kesmodel, & Secher, 2005) and a significantly increased risk of cerebral palsy (Forthun et al., 2016). The amount of weight gained during pregnancy can affect the immediate and future health of a woman and her infant, further leading the Institute of Medicine to publish gestational weight gain

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(GWG) recommendations based on pre-pregnancy BMI (Rasmussen, Catalano, & Yaktine, 2009).

Following pregnancy, postpartum weight retention may lead to an increased risk for obesity onset (Amorim, Rössner, Neovius, Lourenço, & Linné, 2007). A previous study assessing predictors for postpartum weight retention (i.e., retention of excess weight gained during pregnancy) found that over half of women surveyed gained weight (relative to their pre-pregnancy status) one year postpartum (Ohlin & Rössner, 1990). A review by Gunderson and Abrams reported the risk of postpartum weight retention is related to several factors, including dietary intake, lack of physical activity, lactation, smoking status, pre-pregnancy BMI. WG, and parity (Gunderson & Abrams, 2000). Therefore, we hypothesized that pre-pregnancy BMI may be an important predictor of postpartum weight retention following first pregnancy (Lederman, Alfasi, & Deckelbaum, 2002). Maternal postpartum weight retention may be attributed to a variety of factors including socioeconomic status, health behavior (such as physical activity, diet, etc.), and even infant outcomes (Parker & Abrams, 1993). However, to our knowledge, no studies have attempted to identify maternal pre-pregnancy predictors for postpartum weight retention with U.S. population-based data (Ohlin & Rössner, 1990). Other US-based studies have looked at the relationship between pre-pregnancy BMI and postpartum weight retention; however, they are all limited to smaller, more specific populations such as low income, Asian, and participants of the Women, Infants, and Children (WIC) program (Gould Rothberg, Magriples, Kershaw, Rising, & Ickovics, 2011; Koh et al., 2013; Krause, Lovelady, Peterson, Chowdhury, & Østbye, 2010; Oken, Kleinman, Belfort, Hammitt, & Gillman, 2009; Østbye, Krause, Swamy, & Lovelady, 2010; Walker, Timmerman, Sterling, Kim, & Dickson, 2004). A study by Oken et al. utilized a cohort study design to better capture the association between pre-pregnancy BMI and postpartum weight retention but is currently outdated and had a relatively small sample size (Oken et al., 2009). Given growing concerns regarding increased prevalence in maternal obesity, we aimed to address the current gap in the literature concerning maternal weight retention between pregnancies in US women by analyzing recent Washington State birth record data. Specifically, our primary aim was to determine whether pre-pregnancy BMI was associated with maternal weight retention between pregnancies. A secondary aim was to explore the association of GWG during pregnancy on a women's ability to return to her pre-pregnancy BMI before her first birth.

Materials and Methods

Study Design and Data Sources

We conducted a population-based retrospective cohort study. All data related to key exposure variables, outcomes, and covariates were collected from Washington State birth certificate records from 2003–2013. Because all data were de-identified, the Washington State Department of Health Institutional Review Board considered this research to be exempt from review.

Population and Participant Selection

All women mothers who delivered their first live-born child between January 2003 and June 2012 in Washington State were screened for inclusion. Eligible participants were women who had sequential births during this study period (the second birth could be as late as December 2013), with the second birth occurring within 18–36 months of the first delivery date. Women were excluded from the study if their pre-pregnancy BMI was less than 18.5 kg/m^2 or greater than 40 kg/m^2 because pregnant women with unhealthy BMIs are advised to lose or gain weight accordingly, (Meštrović, Roje, Vulić, & Zec, 2017) which would decrease the sensitivity of our analysis. Additionally, we excluded all women with multi-gestational or preterm (<37 weeks) first births, as multi-gestational births are associated with increased gestational weight gain ("Weight Gain During Pregnancy - ACOG," n.d.) and preterm pregnancies are associated with lower gestational weight gain (Goldstein et al., 2017).

Identification of Exposure

The main exposure variable, pre-pregnancy BMI, was calculated using self-reported weight divided by height (kg/m^2). Women were grouped into three categories based on their pre-pregnancy BMI: 18.5 – 24.9 kg/m^2 (normal), 25 – 29.9 kg/m^2 (overweight) and ≥ 30 kg/m^2 (obese). These categories align with the official Centers for Disease Control BMI categories. ("About Adult BMI | Healthy Weight | CDC," 2017). We used the normal BMI group of 18.5 – 24.9 kg/m^2 as our analytic reference group. Ultimately, we included 49,132 women into our study with a 4:1:1 ratio of unexposed (i.e., BMI before first pregnancy 18.5–24.9 kg/m^2) to exposed categories (i.e., BMI before first pregnancy 25 – 29.9 kg/m^2 and BMI 30 – 40 kg/m^2).

Identification of Covariates

Maternal age was calculated based on the women's age at first birth and divided into four categories: <18 years, 18–24, 25–34, and ≥35. Race/ethnicity was categorized into White, Hispanic, Black, Asian (Chinese, Japanese, Filipino, Korean, Vietnamese, Asian Indian or other Asian) and other (other non-white or unknown). GWG was calculated as the difference in weight (in pounds) between a women's pre-pregnancy weight at the start of her first pregnancy and her weight at the time of delivery for her first pregnancy. The Institute of Medicine (IOM) makes different recommendations for weight gain during pregnancy based on pre-pregnancy BMI: 25–35 pounds (lbs) for women in the normal BMI range, 15–25 lbs for women in the overweight BMI range, and 11–20 lbs for obese women. Based on these IOM guidelines, GWG was categorized as follows: "below recommended GWG", "met recommended GWG" or "exceeded recommended GWG". Education was categorized into three categories with <12 years of education, 12 years of education and >12 years of education at the time of first pregnancy. Remaining covariates were dichotomized as yes or no and included ever smoked during pregnancy, enrolled in Women, Infants, and Children (WIC) program, married and, plan to breastfeed after the first birth.

Identification of Outcome

The primary outcome measure was return to pre-pregnancy BMI, which was calculated based on whether a woman returned to her first pre-pregnancy BMI by the start of her second pregnancy. Data were linked for each woman's sequential births to obtain pre-pregnancy BMI values prior to her first and second birth. Return to pre-pregnancy BMI was defined as being no more than 1 kg/m^2 above pre-pregnancy BMI by the start of the second pregnancy. Women with a greater than 1 kg/m^2 increase in BMI were considered not to have had the outcome (failed to return to pre-pregnancy BMI). Due to concerns about possible misclassification of maternal height, we further analyzed the differences in height between first and second pregnancies. We found that 96.1% of the height differences were within 2 inches, which reassured us that we would introduce little bias using the first pregnancy height for both pre-pregnancy and return to pre-pregnancy BMI calculations.

Statistical Analysis

We assessed our primary aim of whether pre-pregnancy BMI (i.e., prior to first pregnancy) was associated with maternal weight retention between pregnancies with stratified analyses of relative risk using the statistical software RStudio version 3.3.1. In line with our secondary aim, we further examined the effects of GWG as a potential effect modifier of our association of interest: given that weight retention and pre-pregnancy BMI are likely to vary by levels of weight gain during pregnancy, we hypothesized that the association between BMI and weight retention might differ by GWG.

We hypothesized the following variables as potential confounders *a priori*: maternal age (<18, 18–24, 25–34, >35), maternal race/ethnicity (White, Hispanic, Black, Asian, or Other), education (<12, 12, >12 years), marital status, and WIC enrollment. All potential confounders were analyzed based on the comparison between crude and adjusted relative risks stratified by the effect modifier GWG. None of these covariates met criteria for confounding as the difference between crude and adjusted RRs was less than 10% for each potential confounder.

Results

Compared with normal BMI and overweight women, obese women were more likely to have smoked during pregnancy, have less than 12 years of education, be enrolled in WIC, and have gestational diabetes, while being less likely to have intent to breastfeed, be married, or be employed (Table 1). Age distributions were similar across the three pre-pregnancy BMI categories. Overweight women were similar to normal BMI women with the exception that they were more likely to be Hispanic, enrolled in WIC, and less likely to be married.

Final results were stratified by GWG categories of below, met or exceeded recommended GWG (Table 2). Overall, 48.5% of women in our study exceeded their GWG recommendation. Among women who met their recommended GWG, obese/overweight women were less likely to return to their pre-pregnancy BMI than women with a normal pre-pregnancy BMI (67.2% and 76.5% respectively; $RR_{Overweight/Obese} = 0.88$; CI: 0.85–0.92). Similar patterns were observed among women who exceeded their recommended GWG

(49.3% and 62.6% returned to pre-pregnancy BMI in overweight/obese and normal BMI categories respectively; $RR_{Overweight/Obese}$ = 0.79, 95% CI: 0.78–0.80). Among women who were below recommended GWG, overweight/obese women showed no statistically significant differences than women with a normal pre-pregnancy BMI in regard to returning to pre-pregnancy BMI ($RR_{Overweight/Obese}$ = 0.99; 95% CI: .92–1.07). A stratified analysis comparing overweight to obese women was also performed and no significant difference in risk between the two groups was found in each of the GWG categories.

Comment

The results of our analyses reaffirmed our hypothesis, indicating that when stratified by GWG, overweight/obese women who met or exceeded their recommended GWG were less likely to return to their pre-pregnancy BMI than normal BMI women who met or exceeded their recommended GWG. A study by Oken et al. included over 2000 women from a Massachusetts pre-birth cohort study finding no difference in GWG by BMI but did not assess return to pre-pregnancy BMI (Oken et al., 2009). Unlike previous research, we utilized recent U.S. data from 2003–2014, and included a heterogeneous cohort. Our study provides updated data on a large, generalizable population surrounding maternal weight retention coinciding with the ongoing problem of maternal obesity in the United States. These results are consistent with a prior study in non-U.S. women which demonstrated that maternal obesity and exceeding recommended GWG are associated with postpartum weight retention (Amorim et al., 2007; Gunderson, 2009).

A limitation of this study was the use of self-reported data when assessing pre-pregnancy BMI. However, previous studies have found that pre-pregnancy weight from clinical records was highly correlated with self-reported maternal weight.[13] Furthermore, our assessment of the differences in height between first and second pregnancies showed that over 96% of maternal height differences were within +/− 2 inches, indicating that height is consistently reported between the two pregnancies.

In this study, we excluded women who delivered preterm (<37 weeks) with their first birth on the rational that preterm pregnancies are associated with lower GWG however this may have induced selection bias into the study (Goldstein et al., 2017). By potentially preferentially decreasing the number of women with lower GWG, this may have reduced the number of women who would have likely returned to their pre-pregnancy BMI. Given this potential for bias, it is important to interpret these results in the setting of full-term gestational births.

Furthermore, having data on women who were healthy enough to have multiple children within a 3-year timespan limits the generalizability of our study. For example, women limited to one child due to a disease or preexisting condition that affects their fertility will not be included in our study. As a result, we may have excluded women who had preexisting conditions that jointly impacted their fertility and weight retention.

Based on these findings, further research to support women during and after their pregnancy to promote behavior changes that prevent excessive weight gain during pregnancy and

weight retention after birth is needed. Doing so will help to identify modifiable risk factors contributing to weight retention prior to second pregnancy with the goal of limiting obesity-associated pregnancy complications. Furthermore, obstetricians, pediatricians, nurse practitioners, nutritionists, or other healthcare providers who interact with pregnant and postpartum women should identify opportunities to further discuss the challenges of weight control and promotion of healthy lifestyle modifications.

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Table 1

Characteristics at first pregnancy among women who had a singleton birth followed by a second pregnancy within 18–36 months in Washington State between 2003–2013

Characteristics	Normal BMI (n = 33,080)		Overweight (n = 8160)		Obese (n =7892)	
	n	%	n	%	n	%
Age (years)						
<18	1151	3.5	245	3.0	199	2.5
18–24	10527	31.8	2855	35.0	3135	39.7
25–34	19053	57.6	4458	54.6	4038	51.2
>/=35	2343	7.1	602	7.4	520	6.6
Race/Ethnicity						
Asian	3478	10.6	462	5.7	279	3.5
Black	786	2.4	231	2.8	269	3.4
Hispanic	1580	4.8	503	6.2	471	6.0
White	26575	80.9	6719	82.3	6529	82.7
Other	411	1.3	185	2.3	269	3.4
Education						
<12	3365	10.2	844	10.4	959	12.2
12	5168	15.7	1491	18.3	1839	23.4
>12	24403	74.1	5795	71.3	5055	64.4
Ever Smoked During Pregnancy						
Yes	1710	5.2	487	6.0	728	9.3
Infant Breastfed						
Yes	31577	96.8	7769	96.7	7388	95.0
Married						
Yes	25808	78.1	6087	74.7	5422	68.8
Enrolled in WIC						
Yes	7533	24.8	2159	28.9	2629	36.2
Missing	2766	8.4	684	8.4	624	7.9
Gestational Diabetes						
Yes	850	2.6	347	4.3	590	7.5

Characteristics	Normal BMI (n = 33,080)		Overweight (n = 8160)		Obese (n =7892)	
	n	**%**	**n**	**%**	**n**	**%**
Employment Status						
Employed	28055	97.3	6927	97.0	6580	95.8
Missing	4249	12.8	1019	12.5	1027	13.0

[a]Percentages among non-missing.. Missing < 5% unless noted

Table 2

Frequency and relative risk of returning to pre-pregnancy body mass index +1 kg/m^2 or less by second pregnancy within 18–36 months with body mass index category prior to first pregnancy stratified by gestational weight gain during first pregnancy, Washington State, 2003–2013

	Returned to Pre-Pregnancy BMI +1 kg/m^2 or less											
	Below Recommended GWG				Met Recommended GWG				Exceeded Recommended GWG			
	n	%	RR	95% CI	n	%	RR	95% CI	n	%	RR	95% CI
Normal	406	80.6	1	Ref	1272	76.5	1	Ref	19128	62.6	1	Ref
Overweight/Obese	1496	79.9	0.99	(0.92 – 1.07)	1653	67.2	0.88	(0.85 – 0.92)	5645	49.3	0.79	(0.78 – 0.80)

(GWG = Gestational Weight Gain; BMI = Body Mass Index)

[a]BMI categories: Normal = 18.5 to 24.9, Overweight/Obese = 25 to 40

[b]GWG categories based on Institute of Medicine recommendations for maternal weight gain during pregnancy by BMI. 25–35 pounds for mothers in the normal BMI category, 15–25 pounds for mothers with in overweight category, 11–20 pounds for mothers in the obese category.