Maternal Obesity and Birth Defects in Rhode Island

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Obesity is a growing problem in Rhode Island. From 2011 to 2017, the prevalence of adult obesity in Rhode Island increased from 25% to 30%.[1] Obese individuals are at an increased risk for many conditions, including heart disease, stroke, and diabetes.[2] According to the Rhode Island Pregnancy Risk Assessment Monitoring System (PRAMS), the prevalence of pre-pregnancy obesity was 21% from 2012-2015, an increase over previous time periods.[3] In pregnant women, obesity has been shown to cause poor maternal and fetal outcomes, including macrosomia, stillbirth, and delivery complications,[4,5] and has been associated with birth defects such as neural tube and congenital heart defects.[5,6,7] The Rhode Island Birth Defects Program's (RIBDP) previous study on the effect of pre-pregnancy obesity on birth defects suggested an association between obesity and certain types of birth defects.[8] As a follow-up to its previous study, the RIBDP has re-examined the relationship between pre-pregnancy obesity and birth defects in newborns to determine if the same associations are seen as obesity becomes more prevalent.

METHODS

In Rhode Island, all healthcare providers and hospitals are required to report children up to the age of five diagnosed with a birth defect to the RIDBP. The RIBDP used this surveillance data to conduct a case control study for Rhode Island resident births from 2015 to 2017. Cases were defined as a newborn diagnosed with a birth defect ICD-10 'Q' code at discharge from the birth hospital and having a Rhode Island maternal residence. Controls were Rhode Island resident births without a reported birth defect diagnosis and were crossmatched with cases to ensure no cases were included.

Starting in 2015, pre-pregnancy height and weight were reported on the birth certificate by the mother at the time of birth. Body mass index (BMI) was calculated using pre-pregnancy height (inches) and weight (pounds) from the Rhode Island Department of Health's Vital Records birth file (BMI = weight/height^2 x 703). Both cases and controls with missing height and/or weight were excluded from analysis. Obesity was defined as having a BMI greater than or equal to 30 kg/cm^2.

Other maternal demographic information was also self-reported by the mother on the birth certificate, including city/town of residence, education, insurance, and race/ethnicity. City/town of residence was defined by core city status (core or non-core). A core city (Central Falls, Pawtucket, Providence, and Woonsocket) has a poverty level higher than 25%.

Medical information related to the pregnancy, including birth weight, gestational age, and diabetes status, were reported to the birth registration system by a physician. Low birth weight was defined as a birth weight less than 2500 grams. Preterm gestational age was defined as a gestational age of less than 37 weeks at birth. For diabetes status, only pre-pregnancy diabetes was included in this analysis.

Demographics for cases and controls were examined to determine if any variables should be controlled for in analysis. Adjusted odds ratios (aOR) were calculated using logistic regression to control for confounding by diabetes status, since diabetes has been associated with both obesity[2] and birth defects.[7] Other demographic variables that were examined and had a significant association were known to be generally associated with birth defects in Rhode Island from previous analyses.[9] P-values less than 0.05 were considered statistically significant. SAS Version 9.4 software was used for analyses (SAS Institute, Cary, NC).

RESULTS

There were 1,036 birth defects cases reported from 2015 to 2017, with 959 (93%) eligible for inclusion in the study. During this time frame, there were 31,255 Rhode Island resident births without birth defects, with 29,206 (93%) eligible for inclusion. **Table 1** shows the demographic characteristics of cases and controls. In cases, 28% of mothers were obese prior to pregnancy, which is slightly higher than controls, where 24% of mothers were obese prior to pregnancy ($p<0.05$). Rates of maternal diabetes (2.0%), low birth weight (16.6%), and preterm gestational age (16.8%) in cases were approximately twice the rate in controls (0.8%, 7.2%, and 8.3%, respectively). Cases were also more likely to be male (61.8%) than controls (50.6%).

Table 2 shows the association between pre-pregnancy obesity and birth defects by body system. After controlling for diabetes, there was a significant association between pre-pregnancy obesity and all birth defects (aOR=1.22, $p<0.01$). Using the National Birth Defects Prevention Network (NBDPN) conditions (47 major anomalies that are

Table 1. Comparison of Demographic Information for Cases and Controls

Variable	Cases (n=959) (%)	Controls (n=29,206) (%)
Obese (BMI >30)*		
Yes	268 (28.0%)	6,965 (23.9%)
No	691 (72.0%)	22,241 (76.2%)
Diabetes (Pre-gestational)*		
Yes	19 (2.0%)	228 (0.8%)
No	939 (97.9%)	28,926 (99.0%)
Birth Weight*		
Low (<2500g)	159 (16.6%)	2,096 (7.2%)
Normal	798 (83.2%)	27,025 (92.5%)
Gestational Age*		
Preterm (<37 weeks)	161 (16.8%)	2,415 (8.3%)
Term	794 (83.1%)	26,695 (91.4%)
Sex*		
Male	593 (61.8%)	14,765 (50.6%)
Female	366 (38.2%)	14,440 (49.4%)
Maternal Age		
<20	48 (5.0%)	1,234 (4.2%)
20-34	722 (75.3%)	22,336 (76.5%)
>34	189(19.7%)	5,636 (19.3%)
City/Town*		
Core**	463 (48.3%)	11,578 (39.6%)
Non-Core	495 (51.6%)	17,628 (60.4%)
Race/Ethnicity*		
Non-Hispanic White	516 (53.8%)	17,346 (59.4%)
Non-Hispanic Black	96 (10.0%)	2,320 (7.9%)
Hispanic	275 (28.7%)	7,119 (24.4%)
Asian	37 (3.4%)	1,502 (5.1%)
Other/Unknown	35 (3.6%)	919 (3.1%)
Insurance*		
Public	625 (65.2%)	16,809 (57.6%)
Private	319 (33.3%)	11,242 (38.5%)
None	7 (0.7%)	191 (0.6%)
Education*		
<12th grade	135 (14.0%)	3,207 (11.0%)
12th grade	204 (22.0%)	5,698 (19.5%)
>12th grade	520 (54.2%)	18,000 (61.6%)

* The p-value was less than 0.05.

**A core city (Central Falls, Pawtucket, Providence, and Woonsocket) has a poverty level higher than 25%.

Table 2. Association between Pre-pregnancy Obesity and Birth Defects, Before and After Controlling for Diabetes, Rhode Island, 2015–2017

Body System	Cases (n)	Unadjusted Odds Ratio (Confidence Interval)	Adjusted Odds Ratio* (Confidence Interval)	p-value for aOR
Overall birth defects	959	1.24 (1.07–1.43)	1.22 (1.06–1.41)	<0.01
NBPDN birth defects	486	1.29 (1.06–1.57)	1.25 (1.03–1.53)	0.03
Cardiovascular defects	296	1.25 (0.98–1.62)	1.23 (0.95–1.59)	0.12
Septal heart defects	183	1.26 (0.91–1.74)	1.25 (0.91–1.73)	0.17
Conotruncal heart defects	20	2.11 (0.86–5.12)	1.87 (0. 74–4.75)	0.19
Obstruction heart defects	20	2.11 (0.64–4.68)	1.77 (0.70–4.54)	0.23
Orofacial defects	47	1.49 (0.80–2.75)	1.45 (0.77–2.72)	0.25
Genitourinary defects	239	1.09 (0.82–1.46)	1.07 (0.79–1.43)	0.68
Musculoskeletal defects	309	1.09 (0.84–1.41)	1.04 (0.80–1.35)	0.79
Central Nervous System	52	1.33 (0.72–2.41)	1.29 (0.69–2.41)	0.42
Respiratory	25	2.93 (1.34–6.42)	2.96 (1.35–6.48)	<0.01
Eye/Ear/Face/Neck	32	1.90 (0.93–3.90)	1.92 (0.94–3.93)	0.08
Digestive	62	1.19 (0.69–2.09)	1.19 (0.68–2.08)	0.54

*The adjusted odds ratio (aOR) was obtained by performing logistic regression, controlling for diabetes status and compares those with birth defects to those without a birth defect.

considered important for national surveillance) as a proxy for more serious birth defects, there was also a significant association seen after adjusting for diabetes (aOR=1.25, p=0.03). The respiratory system was the only body system to show a significant association with obesity (aOR=2.96, p< 0.01).

DISCUSSION

Rhode Island women who were obese prior to pregnancy had an increased risk of having a baby with a birth defect, especially a more serious birth defect tracked by the NBDPN or a respiratory system birth defect. A strong relationship between NBDPN anomalies and pre-pregnancy obesity was also seen in 2007 to 2009 data.[8]

The association between obesity and respiratory system birth defects, such as choanal atresia and pulmonary hypoplasia, was not observed previously. This body system had a small number of cases during this time frame, which limits

any conclusions that may be drawn about its relationship with obesity and should be studied in the future.

Conotruncal heart defects previously showed a strong association with pre-pregnancy obesity (aOR=1.88, p=0.02).[8] An association of a similar magnitude was seen in this study but was not statistically significant. Obstruction heart defects and the eye/ear/face/neck body system also had aORs that suggested an association but were not significant. The small case numbers for these body systems may have limited the ability of this study to detect a significant association. These relationships should be examined in future studies to see if an association is seen with a larger number of cases.

Case numbers were too small to further classify BMI to see if there was a varying effect of BMI class on birth defect outcomes and may have been too small to show a relationship between some body systems and obesity. Information to calculate BMI was first available in the 2015 vital records birth file in Rhode Island, which currently limits the years of recent data available for analysis. Additionally, there may be bias present in height and weight reporting of pre-pregnancy obesity if mothers who self-reported this data used to calculate BMI over- or underestimated these measurements.

Considering the association between birth defects and maternal obesity, if obesity rates continue to increase as has been the trend locally,[1,3] the birth defects rate is likely to increase, which has emotional and financial implications for families of children with birth defects and the healthcare system. Birth defects can cause serious illness or even death, with about one in five infant deaths in Rhode Island attributed to a birth defect.[9] Newborns with a birth defect have an average hospitalization cost approximately 10 times the cost of a newborn without a birth defect and stay in the hospital four times longer on average.[9] As children with a birth defect age, those who were hospitalized have an average length of stay twice that of children without a birth defect.[9] Children with birth defects may also require developmental, educational, and specialty healthcare services.

Not all birth defects can be prevented but focusing on reducing modifiable risk factors, such as obesity, can help reduce the prevalence of birth defects and lead to better outcomes for newborns. Recent PRAMS data estimate that 45% of Rhode Island mothers who were obese prior to pregnancy reported the pregnancy was unintended.[3] With almost half of births to obese women resulting from unintended pregnancies, it is important to incorporate pre-conception messaging into preventive care and public health communications. The RIBDP will increase its messaging focusing on healthy weight as part of its birth defects prevention strategy and work with providers to further disseminate this information to their patients.

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