Maternal Smoking and Birth Defects in Rhode Island

William Arias, MPH, and Samara Viner-Brown, MS

Cigarette smoking has long been associated with poor neonatal conditions such as premature birth[1] and sudden infant death syndrome[2]. Many studies have also shown a link between maternal smoking and congenital anomalies. Pregnant women who smoke are at greater risk for having a baby with a neural tube defect, clubfoot, craniosynostosis and congenital heart defects[3,4]. To follow up on these studies, the Rhode Island Birth Defects Program has examined whether the same relationship exists between maternal smoking and birth defects in Rhode Island.

Methods

This case-control study included live births that occurred in Rhode Island during 2007-2010 among Rhode Island residents. Cases represented newborns with at least one birth defect that were discharged from Women & Infants and Kent hospitals (representing about 80% of the Rhode Island live birth population). A birth defect in Rhode Island is primarily defined as any condition with ICD-9 (International Statistical Classification of Diseases, 9th Edition) codes 740-759.9 and 760.71[5]. Controls were selected using systematic random sampling of newborns from vital records. Smoking exposure among cases was determined by self-reported number of cigarettes smoked per day during pregnancy noted in prenatal records and captured through routine birth defects risk factor surveillance. Smoking exposure among controls was determined by the number of cigarettes smoked per day during pregnancy, which is self-reported on the birth certificate worksheet in vital records. Controls were cross-linked with birth defects cases using their vital record identification number to avoid duplication of study subjects.

Birth defects selected for the study were clubfoot, cryptochidism, cleft/lip palate, pulmonary stenosis, and hypoplastic left heart syndrome. Selected infant and maternal characteristics were used to identify differences in populations for subsequent regression analysis. Frequency and percentages of infant and maternal characteristics were calculated for the case and control populations. Logistic regression was used to measure the exposure-outcome association controlling for gestational age, infant sex, maternal race/ethnicity, city/town of residence, marital status, and for the specific birth defects Down syndrome and amniotic banding. Adjusting for Down syndrome as a potential confounder was necessary to control for the relationship between the chromosomal disorder and congenital heart defects[3]. Births with gestational ages less than 36 weeks were defined as preterm for this study. Core cities are communities where 15% or more of children live in poverty.

Results

During 2007-2010, 1,676 birth defects cases were included in the study. Among the 2007-2010 live birth population (n = 44,732), 3,267 (7.3%) were selected as study controls. Table 1 shows the selected infant and maternal population characteristics

Table 1. Demographic Characteristics of Study Cases and Controls

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Variable		Cases (n=1676) n (%)	Controls (n = 3267) n (%)
Smoker (at least 1 cig/day)			
	Yes	211 (12.6)	315 (9.6)
	No	1465 (87.4)	2952 (90.4)
Multiple Birth			
	Yes	21 (1.3)	140 (4.3)
	No	1655 (98.7)	3127 (95.7)
Gestational Age*			
	Preterm	337 (20.1)	337 (10.3)
	Term	1338 (79.9)	2927 (89.7)
Infant Sex			
	Male	1030 (61.5)	1647 (50.4)
	Female	646 (38.5)	1620 (49.6)
Maternal Age			
	< 20	178 (10.6)	331 (10.1)
	20-34	1182 (70.5)	2401 (73.5)
	> 35	316 (18.9)	535 (16.4)
Core City**			
	Yes	896 (53.5)	1591 (48.7)
	No	780 (46.5)	1676 (51.3)
Race/Ethnicity			
	White	947 (56.7)	2061 (63.4)
	Black	217 (13.0)	307 (9.4)
	Hispanic	404 (24.2)	668 (20.6)
	Native	14 (0.8)	29 (0.9)
	Asian	62 (3.7)	146 (4.5)
Marital Status			
	Not Married	843 (50.3)	1804 (55.2)
	Married	833 (49.7)	1463 (44.8)

** Preterm birth is defined as a gestational age <36 weeks for this study*
*** Core city is defined as a community where 15% or more of children live in poverty*

Table 2. Association Between Maternal Smoking and Birth Defects in Rhode Island, 2007–2010

	Cases (n)	Adjusted OR*	p-value
All birth defects	1676	1.27 (1.05 - 1.55)	0.02
Clubfoot	52	2.24 (1.12 - 4.50)	0.02
Cryptochidism	154	1.14 (0.64 - 2.02)	0.66
Cleft lip/palate	32	1.23 (0.41 - 3.68)	0.71
Pulmonic stenosis**	74	4.56 (2.70 - 7.71)	< .001

** Adjusted for gestational age, infant sex, maternal race/ethnicity, core city status, and maternal status*
*** Conditions affecting the heart were adjusted for Down syndrome*

of cases and controls for RI live births. There were 211 (12.6%) cases and 315 (9.6%) controls with maternal smoking exposure of at least one cigarette/day. There were notable differences between the case and control populations regarding gestational age and infant sex. Specifically, 20.1% of the cases were considered premature compared to 10.3% of the controls. The male-to-female ratio among cases was higher (1.6:1) than the male-to-female ratio among controls (1:1).

Table 2 shows the association between maternal smoking and selected birth defects in Rhode Island, adjusting for selected infant and maternal characteristics, Down syndrome, and amniotic banding. There was a significant association between maternal smoking and all birth defects (aOR = 1.27). Specifically, there were strong, significant associations between maternal smoking and clubfoot (aOR = 2.24), and pulmonic stenosis (aOR = 4.75). Although a positive association existed between maternal smoking and cleft lip/palate (aOR = 1.23) and cryptochidism (aOR = 1.14), there was no statistical significance. There were no hypoplastic left heart syndrome cases found with maternal smoking exposure of at least one cigarette/day.

Discussion

Results from this study show that women who smoked during pregnancy were more likely to give birth to a child with clubfoot or pulmonary stenosis, compared to women who did not smoke. Pulmonic stenosis is a diagnosis typically caused by stenosis of the pulmonary artery, a narrowing of the arteries in the lungs. It can also be caused by a defective pulmonary valve in the heart (pulmonary valve stenosis), but there were an insufficient number of cases in Rhode Island to measure this condition with maternal smoking. A significant number of pulmonic stenosis cases associated with cigarette smoking were found recently in 2009-2010 in Rhode Island, and the RI Birth Defects Program is continuing to monitor this condition.

This study also demonstrated a stronger relationship between clubfoot and maternal smoking than has been identified in previous studies. A recent chart review of clubfoot cases showed no diagnoses for amniotic bands (another cause of clubfoot) [6]. By the end of the first trimester, the foot of the fetus changes to a slight equinovarus adductus position, where the influence of chemicals in cigarettes can produce a permanent arrest throughout the fetal stages[7]. Although aggregating four years of Rhode Island birth defects data helped increase the power of the study, the sample size was still low for cleft lip/palate (n = 32), another condition that has been linked with maternal smoking[8].

There were other limitations to this study. Pierre-Robin syndrome, a known syndrome associated with cleft lip/palate, was not adjusted for regression analysis. Another limitation is that smoking exposure is based on self-report. However, limiting the definition of smoking exposure to "number of cigarettes smoked per day" reduced response bias (records of mothers reporting number of cigarettes smoked per day during pregnancy is likely to be similar between case and control groups than mothers reporting overall smoking during pregnancy without noted number of cigarettes smoked). Another limitation is sample size, which not only limits analysis for congenital heart defects and other anomalies linked with maternal smoking but also limits analysis for a potential exposure-dose relationship.

This study shows that there is a strong relationship between maternal smoking and clubfoot and pulmonary stenosis, although a larger sample size is needed to better understand this relationship with cleft lip/palate. Nevertheless, this study adds further justification for increased tobacco control and prevention among pregnant women to help reduce birth defects in Rhode Island.

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William Arias, MPH, is a Public Health Epidemiologist in the Center for Health Data and Analysis at the Rhode Island Department of Health.

Samara Viner-Brown, MS, is the Chief of the Center for Health Data and Analysis at the Rhode Island Department of Health.

Disclosure of Financial Interests

The authors and/or their spouses/significant others have no financial interests to disclose.

Correspondence

William Arias, MPH
Center for Health Data and Analysis
Rhode Island Department of Health
3 Capitol Hill, Room 407
Providence, RI 02908
e-mail: william.arias@health.ri.gov