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Breastfeeding Duration and Asthma in Puerto Rican Children

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Summary

Rationale—Little is known about breastfeeding and asthma in Puerto Ricans, the ethnic group most affected by this disease in the US. We examined the relation between the currently recommended duration of breastfeeding and asthma in school-aged Puerto Rican children.

Methods—Case-control study of 1,127 Puerto Rican children aged 6 to 14 years living in Hartford, Connecticut (n=449) and San Juan, Puerto Rico (n=678). Parental recall of breastfeeding was categorized based on duration and according to current guidelines (i.e., none, 0–6 months, and >6 months). Asthma was defined as parental report of physician-diagnosed asthma and wheeze in the previous year. We used logistic regression for the multivariate analysis, which was conducted separately for each study site and for the combined cohort. All multivariate models were adjusted for age, gender, household income, atopy, maternal asthma, body mass index, early-life exposure to environmental tobacco smoke, and (for the combined cohort) study site.

Results—After adjustment for covariates, children who were breastfed for up to 6 months had 30% lower odds of asthma (95% CI=0.5–1.0, $P=0.04$) than those who were not breastfed. In this analysis, breastfeeding for longer than 6 months was not significantly associated with asthma (OR=1.5, 95% CI=1.0–2.4, $P=0.06$).

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Conclusions—Our results suggest that breastfeeding for up to 6 months (as assessed by parental recall) is associated with decreased odds of asthma in Puerto Rican children, and that there is no additional beneficial effect of breastfeeding for over 6 months. These results support current recommendations on the duration of breastfeeding in an ethnic group at risk for asthma.

Keywords

Breastfeeding; asthma; children; Puerto Rico

Introduction

Breastfeeding has numerous advantages for the infant, the mother, and society, including developmental, nutritional, immunologic, psychological, social, and economic benefits.¹ Although the benefits of breastfeeding are widely acknowledged, there is still conflicting evidence on its optimal duration in developing and developed countries.² Both the American Academy of Pediatrics and the World Health Organization recommend exclusive breastfeeding for the first 6 months of life.^{1,3}

Asthma is the most common chronic disease of childhood in the US.^{4,5} In this country, the prevalence of childhood asthma is higher in Puerto Ricans (16.1%) than in non-Hispanic blacks (11.2%), non-Hispanic whites (7.7%), or Mexican Americans (5.4%).⁵ For unclear reasons, both Puerto Rican children living in the mainland US and those living in the island of Puerto Rico are disproportionately affected by asthma.⁶

Whereas a protective effect of breastfeeding on asthma in preschool-aged children has been noted across numerous studies,^{7–9} studies in school-aged children (in whom a diagnosis of asthma is more likely to be accurate) have yielded conflicting results. Some^{10–17} but not all^{18–25} studies conducted in older children have found a detrimental effect of breastfeeding on asthma development, particularly in those breastfed for longer periods of time. In a meta-analysis of 31 observational studies published between January 2000 and June 2010, neither any breastfeeding (odds ratio [OR]=0.97, 95% confidence interval [CI]=0.90–1.04) nor exclusive breastfeeding (OR=0.96, 95% CI=0.86–1.06) was associated with wheezing illnesses (including asthma) in children aged 5 to 18 years.²⁶ However, subgroup analysis revealed that any breastfeeding slightly increased the odds of asthma (OR=1.10, 95% CI=1.0–1.22) when asthma was defined by specific criteria (i.e., any two of the following: physician-diagnosed asthma, wheeze in the last 12 months, use of asthma medications in the last 12 months, or airway hyperresponsiveness). Most of the studies conducted to date have used 3 or 4 months as the cut point for the duration of breastfeeding. Therefore, the impact of the currently recommended duration of breastfeeding (i.e., 6 months [see above]) on asthma is still unknown, particularly in high-risk groups such as Puerto Ricans.

We hypothesized that breastfeeding would be associated with asthma in school-aged Puerto Rican children, but that this association would differ according to how long the child was breastfed. To test this hypothesis, we examined breastfeeding and asthma in a case-control study of 1,127 Puerto Rican children aged 6 to 14 years living in Hartford, Connecticut (n=449), and San Juan, Puerto Rico (n=678).

Material and Methods

Subject recruitment

From September of 2003 to July of 2008, children were recruited from 15 public elementary and middle schools in Hartford that enrolled a significant proportion (42%–94%) of Puerto Rican children. As previously described,²⁷ informational flyers with a study description were distributed to all parents of children in grades K to 8 of participating schools by mail (n=10,881) or in person during different school activities (n=885). Parents of 640 children completed a screening questionnaire. Of these 640 children, 585 (91.4%) met inclusion criteria (see below). Parents of 136 of these 585 eligible children refused to participate or could not be reached. There were no significant differences in age, gender, or area of residence between eligible children who did (n=449 [76.8%]) and did not (n=136 [23.2%]) agree to participate.

From March of 2009 to June of 2010, children were recruited from randomly selected households in San Juan. As previously described,²⁸ households in the metropolitan area of San Juan were selected by a multistage probability sampling design. Primary sampling units were randomly selected neighborhood clusters based on the 2000 US census. Secondary sampling units were randomly selected households within each primary sampling unit. A household was included if 1 resident was a child aged 6 to 14 years old. In households with >1 child of this age range, only one child was randomly selected for screening. On the basis of the sampling design, 7,073 households were selected and 6,401 (90.5%) were contacted. Of these 6,401 households, 1,111 had 1 child who met inclusion criteria (see below). In an effort to reach a target sample size of approximately 700 children, we attempted to enroll a random sample (n=783) of these 1,111 eligible children. Parents of 105 of these 783 eligible children refused to participate or could not be reached. There were no significant differences in age, gender, or area of residence between eligible children who did (n=678 [86.6%]) and did not (n=105 [13.4%]) agree to participate.

At both study sites, the main recruitment tool was a screening questionnaire given to parents to obtain information about the child's general and respiratory health. Children ages 6 to 14 years were included in the study if they had four Puerto Rican grandparents (to ensure their Puerto Rican descent). Cases had to have parental report of physician-diagnosed asthma and wheeze in the previous year (n=618). Control subjects had neither parental report of physician-diagnosed asthma nor wheeze in the prior year (n=509).

Study Procedures

Study participants completed a protocol that included questionnaires, spirometry, and collection of blood (for measurement of serum total and allergen-specific IgEs).

One of the child's parents (usually [>93%] the mother) completed a questionnaire that was slightly modified from the one used in the Collaborative Study of the Genetics of Asthma.²⁹ This questionnaire was used to obtain information about the child's general and respiratory health (including a history of any breastfeeding, prematurity, low birth weight, and mode of delivery), socio-demographic characteristics, maternal asthma, current exposure to

environmental tobacco smoke (ETS), and early-life exposure to ETS (in utero or prior to 2 years of age).

Height and weight were measured to the nearest centimeter and pound, respectively. Spirometry was conducted with an Easy One spirometer (NDD Medical Technologies, Andover, MA). All participants had to be free of respiratory illnesses for 4 weeks, and they were also instructed to avoid (when possible) the use of inhaled short- and long-acting bronchodilators for 4 and 12 hours before testing, respectively. Forced expiratory maneuvers were judged to be acceptable if they met or exceeded the American Thoracic Society criteria modified for children.³⁰ The best forced expiratory volume in 1 second (FEV₁) and forced vital capacity (FVC) were selected for data analyses.

Serum levels of total IgE and IgEs specific to common allergens (dust mite [Der p 1], cockroach [Bla g 2], cat dander [Fel d 1], dog dander [Can f 1], and mouse urinary protein [Mus m 1]) were determined using the UniCAP 100 system (Pharmacia & Upjohn, Kalamazoo, MI). For each allergen, an IgE 0.35 IU/ml was considered positive.

Written parental consent was obtained for participating children, from whom written assent was also obtained. The study was approved by the Institutional Review Boards of Connecticut Children's Medical Center (Hartford, CT), the University of Puerto Rico (San Juan, PR), Brigham and Women's Hospital (Boston, MA), and the University of Pittsburgh (Pittsburgh, PA).

Statistical analysis

The main exposure of interest was a history of any breastfeeding, which was categorized for our main analysis according to current guidelines as: none, 0 to 6, and >6 months.^{1,3} Our outcome of interest was asthma, defined as physician-diagnosed asthma and wheeze in the previous year.

The analysis of breastfeeding duration and asthma was first conducted for each study site and then for the combined cohort. Bivariate analyses were conducted using one-way analysis of variance (ANOVA) for continuous variables and the Cochran-Armitage trend tests for categorical variables. For the multivariate analysis, we used a stepwise approach to build the logistic regression models. Because of their well-established association with breastfeeding and/or asthma, all models included age,⁵ gender,³¹ household income (< vs. \$15,000/year [near the median income for households in Puerto Rico in 2008–2009³²]),³³ maternal asthma,³⁴ early-life exposure (in utero or prior to 2 years of age) to environmental tobacco smoke (ETS),³⁵ and (for the combined cohort) study site.⁶ The following covariates were also included in the initial multivariate models if they were associated with asthma at $P \leq 0.20$ in bivariate analyses: body mass index as a z-score (based on 2000 CDC growth charts³⁶), prematurity, low birth weight (<2,500 g), mode of delivery (caesarean vs. vaginal birth), total IgE (transformed to a logarithmic [log₁₀] scale), atopy (defined as ≥ 1 positive [≥ 0.35 IU/ml] allergen-specific IgE), current exposure to ETS, parental education (≥ 1 parent completed high school vs. none), type of health insurance (private or employer-based health insurance vs. others), and lung function measures (FEV₁ and FEV₁/FVC). These additional covariates remained in the final models if they were associated with asthma at $P < 0.05$ or if

they changed the parameter estimate (β) by 10%. After the final models were built, we tested for first-order interactions between any breastfeeding and the other covariates in the models. As an exploratory analysis, we used different cut points for the duration of breastfeeding (i.e., none, 0–2, 2–4, 4–6, 6–8, 8–10, and >12 months) in the final models. Statistical significance was defined as a $P < 0.05$. All statistical analyses were performed using SAS version 9.3 (SAS Institute, Cary, NC).

Results

The baseline characteristics of study participants are summarized in Table 1. At each study site and in the combined cohort, cases were significantly more likely to have maternal asthma and to be atopic, and to have a higher total IgE and a lower FEV₁/FVC than controls. Compared to controls in the combined cohort, cases were also significantly more likely to be male, premature, breastfed for over 6 months, exposed to ETS (currently or in early life), and to have a higher body mass index and a lower FEV₁.

Table 2 shows the bivariate analyses of breastfeeding duration and the covariates of interest. In the combined cohort, age, prematurity, low birth weight, low household income, low parental education, no private or employer-based insurance, and exposure to ETS in early life were all significantly and inversely associated with breastfeeding for over 6 months.

Table 3 shows the results of the main analysis of breastfeeding duration and asthma. In the unadjusted analysis, breastfeeding duration was not significantly associated with asthma at either study site or in the combined cohort. In the multivariate analysis of the combined cohort, children who were breastfed for 6 months or less had significantly lower (30% lower) odds of asthma than those who were not breastfed. In this analysis, breastfeeding for over 6 months was non-significantly associated with a 50% increment in the odds of asthma when compared to no breastfeeding. We found no significant modification of the estimated effect of breastfeeding duration on asthma by any of the covariates in the final multivariate models.

We found similar results in an exploratory analysis using different cut points for the duration of breastfeeding (Table 4). In particular, the effect estimates for the categories between 0–6 months (i.e., 0–2, 2–4, and 4–6 months) suggested a protective effect on asthma when compared to no breastfeeding, while the effect estimates for the categories above 6 months (6–8, 8–10, 10–12, and >12 months) did not. In this exploratory analysis, only the 0–2 months category attained statistical significance, likely due to the small number of participants in each of the other groups.

Discussion

Since early-life exposures can affect the subsequent occurrence of respiratory diseases such as asthma,^{37,38} there is considerable interest in identifying environmental or lifestyle exposures that can be modified in infancy to prevent childhood asthma, particularly in high-risk children. In this study, we found that breastfeeding for up to 6 months is significantly associated with decreased odds of asthma in Puerto Rican children. On the other hand, breastfeeding for more than 6 months does not appear to confer additional beneficial effects

in this ethnic group. To our knowledge, this is the first study of breastfeeding and asthma in Puerto Ricans.

There are several proposed mechanisms by which breastfeeding might decrease the development of asthma in children, including transmission of immune-modulatory factors that directly affect the child's immune system or stimulate alveolarization (e.g., cytokines, immunoglobulins, polyunsaturated fatty acids, and chemokines),^{39,40} reduction in the frequency and severity of respiratory infections,^{1,41} and/or enhanced development of the neonatal intestinal flora.^{9,41}

Our results differ from those studies suggesting that breastfeeding (regardless of duration) increases the risk of asthma in school-aged children.^{10–17} In a birth cohort study of 1,037 children in New Zealand, any breastfeeding for 4 weeks or longer was associated with 1.8 times higher odds of asthma from ages 9 to 26 years (95% CI for OR=1.4–2.5).¹⁰ Similar results were found in another birth cohort study of 1,043 children in the US, in which exclusive breastfeeding for at least 4 months was associated with nearly nine-fold increased odds (95% CI for OR=3.4–22.2) of asthma at ages 6 to 13 years.¹⁵ In that study; however, results from stratified analyses showed that the observed association was only significant in atopic children with asthmatic mothers. In contrast to studies showing detrimental effects of breastfeeding on asthma, many others have shown null^{18–20} or protective^{21–25} estimated effects of breastfeeding on asthma. For example, a birth cohort study of 3,115 Dutch children showed that any breastfeeding for more than 4 months reduced the odds of asthma at age 8 years by approximately 40% (95% CI for OR=0.4–0.8).²¹

The discrepant findings among our study and others may be partly explained by differences in study population, definition of asthma used, study design, and the cut points selected to study the duration of breastfeeding. Our definition of asthma has been employed in very large epidemiological studies and is well correlated with increased airway responsiveness.⁴² Unlike some previous studies, we formally tested for interactions between breastfeeding and other covariates prior to conducting any stratified analysis (thus reducing the risk of obtaining spurious results). We also accounted for multiple potential confounders (including measurements of serum total IgE, allergen-specific IgEs, and lung function). Finally, we based our choice of cut points for the duration of breastfeeding on current recommendations by national and international organizations.^{1–3}

Although our study has considerable strengths, we also recognize several limitations to our findings. Firstly, this is a cross-sectional case-control study. Thus, mothers of children who had developed asthma by school age may have a better recall of breastfeeding patterns than mothers of healthy children. However, long-term recall of the duration of breastfeeding (up to 20 years after delivery) has been shown to be highly accurate in other studies.⁴³ Secondly, mothers with asthma may have decided to breastfeed longer due to the known benefits of human milk. However, this is an unlikely source of bias in our study because maternal asthma was not significantly associated with breastfeeding duration. Thirdly, we had no data on the exclusivity of breastfeeding. However, the duration of breastfeeding appears to be a more important determinant of health conditions than its exclusivity,⁴⁴ and it is likely that using exclusive breastfeeding instead of any breastfeeding would have actually strengthened

the observed associations. Fourthly, selection bias is possible in any observational study such as ours. However, the participation rates among eligible children in Hartford and San Juan were ~77% and ~87%, respectively, which are high for a study of an ethnic minority group. Even though our results were more significant in San Juan than in Hartford, they were of similar magnitude and in the same direction across study sites in spite of differences in recruitment approach and sample size. Fifthly, there could be residual confounding by unmeasured variables (e.g., maternal or infant's diet, composition of breast milk, or lower respiratory infections), which may partly explain our non-significant findings for more prolonged (>6 months) breastfeeding. Lastly, our results may not be generalizable to non-Puerto Rican children. However, our findings are relevant to the group at highest risk for asthma morbidity in the US.

In conclusion, our results suggest that any breastfeeding for up to 6 months (as assessed by parental recall) reduces the odds of childhood asthma in Puerto Ricans and that breastfeeding for more than 6 months does not appear to confer additional beneficial effects in this ethnic group. These results support current recommendations on the duration of breastfeeding by the American Academy of Pediatrics and the World Health Organization.^{1,3} Further work is needed to clarify the role of breastfeeding in the pathogenesis of asthma.

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Dr. Cloutier serves as a consultant for GlaxoSmithKline on a topic unrelated to this manuscript. Dr. Celedón served as a single-time consultant for Genentech in 2011 on a topic unrelated to this manuscript.

Abbreviations

CI	Confidence interval
ETS	Environmental tobacco smoke
FEV₁	Forced expiratory volume in 1 second
FVC	Forced vital capacity
OR	Odds ratio

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Table 1

Baseline characteristics of participating Puerto Rican children according to study site and case-control status^{a,b}

Covariate	Hartford		San Juan		Combined	
	Controls (n=182)	Cases (n=267)	Controls (n=327)	Cases (n=351)	Controls (n=509)	Cases (n=618)
Age (years)	9.7(2.8)	9.9(2.8)	10.5(2.7)	10.0(2.6) ^c	10.2(2.8)	10.0(2.7)
Female sex	96(52.8%)	134(50.2%)	168(51.4%)	150(42.7%) ^c	264(51.9%)	284(46.0%) ^c
Any breastfeeding						
No	98(56.7%)	135(54.7%)	142(44.4%)	159(45.6%) ^c	240(48.7%)	294(49.3%) ^c
0–6 months	61(35.3%)	77(31.2%)	140(43.8%)	126(36.1%)	201(40.8%)	203(34.1%)
>6 months	14(8.1%)	35(14.2%)	38(11.9%)	64(18.3%)	52(10.6%)	99(16.6%)
BMI (z-score)	0.8(1.3)	1.1(1.2) ^c	0.5(1.1)	0.7(1.2)	0.6(1.2)	0.9(1.2) [‡]
Obesity (BMI >95 th percentile for age and sex)	54(29.8%)	100(37.7%)	53(17.9%)	69(22.1%)	107(22.4%)	169(29.3%) ^c
Total IgE (IU/ml) ^d	63.1(4.4)	112.2(4.9) ^c	151.4(4.7)	295.1(4.8) ^c	109.6(4.8)	190.5(5.1) ^c
Atopy (≥ 1 positive allergen-specific IgE)	63(42.6%)	130(57.5%) ^c	143(49.8%)	210(68.9%) ^c	206(47.4%)	340(64.0%) ^c
Current exposure to ETS	77(43.0%)	125(47.5%)	113(34.6%)	155(44.2%) ^c	190(37.6%)	280(45.6%) ^c
Exposure to ETS in utero or prior to 2 years of age	91(50.8%)	154(58.6%)	131(40.2%)	174(49.6%) ^c	222(44.0%)	328(53.4%) ^c
Household income <\$15,000/year	108(66.3%)	148(62.5%)	196(62.8%)	225(65.4%)	304(64.0%)	373(64.2%)
Neither parent graduated from high school	45(24.9%)	89(33.5%)	64(19.6%)	63(18.0%)	109(21.5%)	152(24.6%)
No private or employer-based health insurance	125(77.2%)	187(78.2%)	205(62.7%)	239(68.1%)	330(67.5%)	426(72.2%)
Maternal asthma	50(28.1%)	124(47.0%) ^c	67(20.8%)	172(49.3%) ^c	117(23.4%)	296(48.3%) ^c
Prematurity	7(3.9%)	17(6.5%)	15(4.6%)	31(8.9%) ^c	22(4.4%)	48(7.9%) ^c
Low birth weight (<2500g)	11(6.3%)	15(5.9%)	14(4.5%)	18(5.2%)	25(5.1%)	33(5.5%)
Birth by caesarean section	31(21.4%)	48(23.2%)	108(33.4%)	131(37.4%)	139(29.7%)	179(32.1%)
FEV ₁ (l) ^e	2.0(0.7)	1.9(0.7)	2.1(0.7)	1.9(0.7) ^c	2.0(0.7)	1.9(0.7) ^c
FEV ₁ /FVC	0.85(0.1)	0.82(0.1) ^c	0.84(0.1)	0.81(0.1) ^c	0.84(0.1)	0.81(0.1) ^c

Definition of abbreviations: BMI = Body mass index; ETS = Environmental tobacco smoke; FEV₁ = Forced expiratory volume in 1 second; FVC = Forced vital capacity.^a Data presented as the number (%) for binary and categorical variables or mean (standard deviation) for continuous variables.^b Percentages were calculated for children with complete data.

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$P < 0.05$ for the comparison between cases and controls.
 $d_{Total\ IgE}$ transformed to a logarithmic ($\log 10$) scale. Results shown as geometric mean (standard deviation).
 d_{FEV_1} presented as absolute values because of lack of predicted values for Puerto Ricans.

Table 2

Baseline characteristics of participating Puerto Rican children according to study site and duration of breastfeeding^{a,b}

Covariate	Hartford			San Juan			Combined		
	Any breastfeeding (months)			Any breastfeeding (months)			Any breastfeeding (months)		
	No (n=233)	0-6 (n=138)	>6 (n=49)	No (n=301)	0-6 (n=266)	>6 (n=102)	No (n=534)	0-6 (n=404)	>6 (n=151)
Age (years)	10.1(3.0)	9.3(2.5)	9.8(2.8) ^c	10.5(2.7)	10.1(2.7)	9.9(2.4)	10.3(2.8)	9.8(2.7)	9.9(2.5) ^c
Female sex	116(49.8%)	69(50.0%)	29(59.2%)	137(45.5%)	124(46.6%)	50(49.0%)	253(47.4%)	193(47.8%)	79(52.3%)
BMI (z-score)	0.9(1.3)	0.9(1.3)	1.1(1.1)	0.5(1.2)	0.6(1.1)	0.8(1.1)	0.7(1.3)	0.7(1.2)	0.9(1.1)
Obesity (BMI >95 th percentile for age and sex)	78(33.8%)	48(34.8%)	17(34.7%)	54(19.6%)	43(18.3%)	24(27.0%)	132(26.0%)	91(24.4%)	41(29.7%)
Total IgE (IU/ml) ^d	91.2(4.5)	81.3(5.0)	13.8(11.2)	199.5(4.9)	223.9(5.0)	245.5(4.5)	141.3(5.0)	154.9(5.4)	162.2(5.1)
Atopy (1 positive allergen-specific IgE)	98(52.1%)	62(52.1%)	23(48.9%)	152(56.5%)	146(63.2%)	50(60.2%)	250(54.7%)	208(59.4%)	73(56.2%)
Current exposure to ETS	111(48.3%)	57(41.3%)	21(42.9%)	126(41.9%)	105(39.5%)	35(34.3%)	237(44.6%)	162(40.1%)	56(37.1%)
Exposure to ETS in utero or prior to 2 years of age	134(58.3%)	75(54.4%)	21(42.9%)	146(48.7%)	118(44.4%)	37(36.3%) ^c	280(52.8%)	193(47.8%)	58(38.4%) ^c
Household income <\$15,000/year	139(68.5%)	77(60.6%)	18(41.9%) ^c	211(73.3%)	142(55.0%)	61(59.8%) ^c	350(71.3%)	219(56.9%)	79(54.5%) ^c
Neither parent graduated from high school	80(34.6%)	33(23.9%)	10(20.4%) ^c	70(23.3%)	41(15.4%)	12(11.8%) ^c	150(28.2%)	74(18.3%)	22(14.6%) ^c
No private or employer-based health insurance	163(80.7%)	94(74.0%)	35(76.1%)	228(75.8%)	152(57.1%)	59(57.8%) ^c	391(77.7%)	246(62.6%)	94(63.5%) ^c
Maternal asthma	90(39.7%)	57(41.3%)	20(40.8%)	100(33.8%)	92(34.6%)	45(44.6%)	190(36.3%)	149(36.9%)	65(43.3%)
Prematurity	14(6.0%)	7(5.2%)	1(2.1%)	29(9.7%)	12(4.5%)	4(4.0%) ^c	43(8.1%)	19(4.7%)	5(3.4%) ^c
Low birth weight (<2500g)	16(7.2%)	8(5.9%)	0	21(7.2%)	9(3.4%)	1(1.0%) ^c	37(7.2%)	17(4.2%)	1(0.7%) ^c
Birth by caesarean section	41(24.7%)	25(20.7%)	9(21.4%)	121(40.5%)	83(31.2%)	35(34.3%)	162(34.8%)	108(27.9%)	44(30.6%)
FEV ₁ (l) ^e	2.0(0.8)	2.0(0.8)	2.0(0.7)	2.0(0.7)	2.0(0.7)	1.9(0.6)	2.0(0.7)	1.9(0.7)	1.9(0.6)
FEV ₁ /FVC	0.8(0.1)	0.8(0.1)	0.8(0.1)	0.8(0.1)	0.8(0.1)	0.8(0.1)	0.8(0.1)	0.8(0.1)	0.8(0.1)

Definition of abbreviations: BMI = Body mass index; ETS = Environmental tobacco smoke; FEV₁ = Forced expiratory volume in 1 second; FVC = Forced vital capacity.^a Data presented as the number (%) for binary variables or mean (standard deviation) for continuous variables.^b Percentages were calculated for children with complete data.^c $P < 0.05$ for the comparison between breastfeeding groups.^d Total IgE transformed to a logarithmic (log10) scale. Results shown as geometric mean (standard deviation).

FEV₁ presented as absolute values because of lack of predicted values for Puerto Ricans.

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Table 3Main analysis of any breastfeeding and asthma in participating Puerto Rican children according to study site^{a,b}

	Hartford	San Juan	Combined
<u>Unadjusted</u>			
Any breastfeeding			
No	Ref.	Ref.	Ref.
0–6 months	0.9(0.6–1.4), 0.6	0.8(0.6–1.1), 0.2	0.8(0.6–1.1), 0.1
>6 months	1.9(0.9–3.8), 0.09	1.5(0.9–2.3), 0.1	1.5(1.0–2.3), 0.03
<u>Adjusted^c</u>			
Any breastfeeding			
No	Ref.	Ref.	Ref.
0–6 months	0.8(0.5–1.3), 0.3	0.7(0.5–1.0), 0.06	0.7(0.5–1.0), 0.04
>6 months	1.7(0.8–3.7), 0.2	1.4(0.8–2.5), 0.2	1.5(1.0–2.4), 0.06
Maternal asthma	2.7(1.6–4.4), <0.001	4.0(2.7–5.9), <0.001	3.4(2.5–4.7), <0.001
BMI (z-score)	1.2(1.0–1.4), 0.1	1.1(1.0–1.3), 0.1	1.1(1.0–1.3), 0.03
Exposure to ETS in utero or prior to 2 years of age	1.5(0.9–2.4), 0.1	1.6(1.1–2.3), 0.02	1.5(1.1–2.1), 0.004

Definition of abbreviations: BMI = Body mass index; ETS = Environmental tobacco smoke.^aData presented as odds ratio (95% confidence interval), *P* value.^bAsthma defined as physician-diagnosed asthma and wheeze in the previous year.^cMultivariate models were adjusted for age, gender, household income, and atopy in addition to the covariates listed in each column. Analyses of the combined group were also adjusted for study site.

Table 4

Exploratory analysis of breastfeeding and asthma in participating Puerto Rican children in the combined dataset using different categories for breastfeeding duration^{a,b}

Any breastfeeding	Odds ratio (95% confidence interval), P value
No	Ref.
0–2 months	0.6(0.5–0.9), 0.02
2–4 months	0.9(0.6–1.3), 0.5
4–6 months	0.6(0.2–1.8), 0.3
6–8 months	1.6(0.9–3.0), 0.1
8–10 months	2.9(0.3–25.2), 0.3
10–12 months	1.5 (0.6–3.4), 0.4
>12 months	1.4(0.6–3.1), 0.4

^a Asthma defined as physician-diagnosed asthma and wheeze in the previous year.

^b Results from a multivariate model adjusted for age, gender, household income, atopy, maternal asthma, BMI z-score, exposure to ETS in utero or prior to 2 years of age, and study site.