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Authors

McCallister, Margaret
Medrano, Rosalinda
Wojcicki, Janet

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Early life obesity increases the risk for asthma in San Francisco born Latina girls

Margaret McCallister, Rosalinda Medrano, B.S., and Janet Wojcicki, Ph.D., M.P.H.

ABSTRACT

Background: *Previous studies showed that youths who are obese are more likely to have asthma; however, some studies found important sex differences in the risk for asthma.*

Methods: *We retrospectively assessed the asthma incidence in a Latino cohort of children recruited from birth and followed up until 9 years of age. We subsequently assessed risk factors for asthma and for an early asthma (defined as <4 years of age) diagnosis in relation to obesity. Asthma was assessed via maternal reports and medical records review of the children at 9 years of age. Each child's weight and height were collected annually. Independent and sex-specific risk factors for asthma diagnosis were assessed by using multivariable logistic regression models.*

Results: *In our cohort, 24.6% (42/164) of the children were diagnosed with asthma by 9 years of age. The mean ± standard deviation age of asthma diagnosis was 29.5 ± 4.5 months; 79.5% had a diagnosis of asthma at <4 years of age. In girls, any breast-feeding at 6 months was associated with a reduced risk of asthma (odds ratio [OR] 0.21 [95% confidence interval {CI}, 0.05–0.86]) and obesity at 2 years of was associated with increased risk for asthma (OR 12.14 [95% CI 2.79–53.05]). Exposure to environmental toxins and consumption of sugar-sweetened beverages were associated with a risk for asthma diagnosis after 4 years of age.*

Conclusion: *In our high-risk Latino cohort, obesity was associated with asthma development in the girls. In addition, an asthma diagnosis after 4 years of age may be related to environmental toxin exposure and early consumption of sugar-sweetened beverages compared with an earlier diagnosis.*

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According to the National Institute of Diabetes and Digestive and Kidney Diseases, 31.8% of children ages 2–19 years old in 2012 were either overweight or obese, and 16.9% were obese.[1] In California, in 2015, 15.1% of 10–17 year olds were obese.[2] In addition to metabolic diseases, such as type 2 diabetes mellitus and nonalcoholic fatty liver disease, children with obesity are more likely to develop allergic and inflammatory conditions, *e.g.*, asthma. Previous studies have found that children who are obese are at a greater risk for asthma development and that children who are obese are more likely to develop more severe asthma, although no causal relationship has been determined.[3] There may be sex differences in the relationship between obesity and the risk for asthma explained *via* a differential impact of hormonal mechanisms. There are conflicting results, with a meta-analysis finding an increased risk for boys who are overweight,[4] whereas other studies found an increased risk for girls.[5–7] Independent of sex effects, an increase in weight gain may be particularly important in the first 6 years of life for risk of asthma.[8]

In comparison with whites, Latinos are more likely to be obese,[8] including children and adolescents.[9] Previous studies with high-risk, minority children at high risk found that, for both sexes, children with obesity are also more likely to have asthma across age groups.[10,11] Meanwhile, in California, African-American and white children had higher reported rates of asthma than Latino children, despite the high rate of obesity in Latino children.[12] Of all Latino population groups, children of Mexican and Central American origin had the lowest rate of asthma (13.3% and 14.4 lifetime risk, respectively) in the California Healthy Kids Survey, administered in public schools between 2001 and 2003.[12] In an urban Latino cohort of primarily children of Mexican and Central American origin with a high prevalence of obesity and a theoretically lower risk for asthma, we assessed asthma incidence and risk factors, with a focus on obesity and weight gain in relation to asthma development.

METHODS

Participants

Self-identified Latina women in the second and third trimesters of pregnancy who did not have insulin-

From the Department of Pediatrics, University of California, San Francisco, California
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Address correspondence to Janet M. Wojcicki, Ph.D., Department of Pediatrics (Gastroenterology, Hepatology and Nutrition), University of California San Francisco, 550 16th Street, 94143 San Francisco, CA
E-mail address: janet.wojcicki@ucsf.edu

treated gestational diabetes or preexisting diabetes mellitus were recruited at prenatal clinics at the University of California, San Francisco Medical Center and at San Francisco General Hospital between May 2006 and May 2007 ($N = 201$). Details of inclusion and exclusion criteria were previously described on this longitudinal cohort, the Hispanic Eating and Nutrition (HEN) cohort.[13,14,15] These women were followed up through labor and delivery, and, subsequently, were annually interviewed from the time their children were born until their children were 9 years of age. This cohort and their inclusion and exclusion criteria were previously described.[14,15] Briefly, exclusion criteria were maternal self-reported drug or alcohol abuse, preexisting diabetes mellitus or gestational diabetes mellitus treated with insulin, polycystic ovarian syndrome, eating disorders (*e.g.,* bulimia or anorexia nervosa), or any health problems that would influence breast-feeding. Infants at delivery were excluded if they had special care needs, chronic disease, or Apgar scores of <7 at 5 minutes. All the women provided written consent for their participation and for their children's participation. The study was approved by the institutional review board at the University of California (Committee on Human Research) (11–06334).

Procedures

After receiving informed consent, baseline data and sociodemographics of the mothers, including age, education, occupation, income, marital status, language used, and the length of time in the United States, were collected. The children's medical history was ascertained through chart review and annual interviews with the mothers. In addition, annual questionnaires and interviews with the mothers were used to determine the children's dietary habits and to assess children and maternal anthropometrics, including weight and height measurements.[14,15] Obesity was defined as ≥95th percentile body mass index according to the Centers for Disease Control age and sex-standardized growth charts.[16] Early chronic obesity was defined as obesity from 1 to 3 years of age, and late chronic obesity was defined as obesity at both 5 and 9 years of age. When they were 9 years of age, the children's medical records were assessed for a history of asthma and the mothers were interviewed by a trained research assistant for asthma diagnosis, including age of diagnosis, by using questions from the National Health and Nutrition Examination Survey.[17] Dietary intake, including consumption of sugar-sweetened beverages, was ascertained annually by using a food frequency questionnaire, and high consumption of sugar-sweetened beverages was defined as consuming four or more beverages per week.

Environmental Analysis

To assess environmental exposures, we used a tool published by The Office of Environmental Health Hazard Assessment in lieu of the California Environmental Protection Agency: CalEnviroScreen 1.0 (Sacramento, CA). This tool provides a metric for assessing the environmental risk by ZIP Code on a scale of 0 (least exposed) to 40 (most exposed).[18] The system analyzes both pollution burden (including ozone concentrations, particulate matter (PM) PM2.5 concentrations, diesel particulate matter (PM) emissions, pesticide use, toxic releases from facilities, traffic density, cleanup sites, groundwater threats, hazardous waste, impaired water bodies, solid waste sites and facilities) and population characteristics (including prevalence of children and elderly, rate of low birth weight births, asthma emergency department visits, educational attainment, linguistic isolation, and poverty) to provide a metric for overall environmental risk.[18]

We used the ZIP Code areas inhabited by our participants, both at birth and at their most current visit (presumably, their 9-year interview) to assess environmental exposures. Among our participants, the range of ZIP Code scores at birth was 5.49 to 42.78, with a mean of 23.05, whereas the range of current ZIP Code scores was 6.79 to 47.29, with a mean of 26.76. Thus, a delineation was made for the purposes of analysis with a ZIP Code with a score of ≥20 was classified as high risk, whereas a score of <20 was low risk.

Statistical Analysis

The primary outcome of interest was asthma diagnosis based on maternal self-report. Our primary predictor of interest was obesity at each annual measurement and chronic obesity.[19] Secondary predictors included factors previously determined to be associated with asthma or childhood obesity, either in our previous studies or other publications[13,14,15], including child sex, delivery type (vaginal or cesarean section), exclusive breast-feeding or any breast-feeding at different time points in the first year, maternal education level, environmental toxin exposure (by using the aforementioned CalEnviroScore 1.0 application), and Latino ethnicity (Mexican versus Central/South American).[20] To assess the relationship between an asthma diagnosis and dichotomous predictors, χ^2 tests were used, and *t*-tests were used for continuous predictors. Logistic regression was used to calculate odds ratios (OR). For those children who were lost to follow up or who we were unable to assess and diagnose asthma ($n = 37$), we compared maternal age at enrollment, self-reported ethnicity, and child sex by using Student *t*-tests and χ^2 tests for dichotomous predictors.

Multivariable logistic regression was used to look for independent predictors of asthma diagnosis in a

child by age 9 years. Variables with a statistical significance of $p < 0.05$ in bivariate analysis or previous studies[13,14,15,19] that found significant or that had potential biologic plausibility for asthma were analyzed in a multivariable logistic regression model. These were then stratified by sex and again analyzed in separate multivariable logistic regression models. We also assessed risk factors for an asthma diagnosis before age 4 years by using the same predictors (χ^2 tests and multivariate linear analysis), discussed above compared with those with a later diagnosis. These results are presented only in the text and not in tabular format, given the small number of outcomes ($n = 38$; with 30 diagnosed before age 4 years).

RESULTS

Of the 164 participants for whom we were able to obtain data history of asthma diagnosis and body mass index at age 9 years, 22.6% had a history of asthma ($n = 38$), with a mean age of diagnosis of ~29.5 months or 2.5 years of age. Thirty of the 38 had asthma diagnosed before age 4 years. Of the 164 in the cohort, 50.5% were girls and 49.5% were boys; 14.4% were born by cesarean section and 85.6% were born by vaginal delivery. The ethnic composition of the group was 61.19% Mexican, 33.33% Central American, and 5.48% other Hispanic groups. Compared with those children who were still in the cohort at age 9 years, those who were lost to follow up did not differ in terms of child's sex ($p = 0.95$), parent's marital status ($p = 0.82$) at enrollment, breast-feeding status at 6 months of age ($p = 0.12$), or self-reported maternal ethnicity ($p = 0.29$).

Child Exposures and Risk of Asthma

We did not find any differences between obesity and asthma diagnosis at different time points in childhood and type of delivery (vaginal versus cesarean section), child sugar sweetened beverage consumption, neighborhood environmental exposures, maternal ethnicity, and education level, and asthma diagnosis (Table 1). Breast-feeding rates were higher in those children who did not have any reported asthma compared with children who did reach statistical significance for any breast-feeding at child's age of 6 months (69.49 of children who developed asthma versus 47.50% of children who did not; $p = 0.01$) and breast-feeding at 1 year (45.05 of children who developed asthma versus 22.50% of children who did not; $p = 0.01$) (Table 1). Any breast-feeding of their baby at 4–6 weeks of age neared statistical significance (93.33 of children who developed asthma versus 83.33% who did not; $p = 0.06$).

In stratifying by sex, we found significant differences in the risk for asthma by sex in relation to obesity. Obesity rates were higher in boys at 2 years of age who did not have asthma (23.21 versus 4.17%), yet bordered on statistical significance ($p = 0.07$) (Table 2); whereas girls who were obese at 6 months ($p = 0.03$) and at 2, 3, and 4 years of age ($p < 0.01$, $p = 0.02$, $p = 0.03$, respectively), and those with chronic obesity from ages 1 to 3 years ($p = 0.01$) were more likely to have been diagnosed with asthma (Table 3). We also found that, for the girls, any breast-feeding at 6 months and 1 year of age were associated with a reduced risk of asthma (for 6 months and 1 year of life; $p = 0.03$ and $p = 0.04$, respectively).

Risk Factors for Later Asthma Diagnosis (≥4 years of age)

When assessed by age of diagnosis, our study indicated that children who were diagnosed with asthma at or after 4 years of age were more likely than those diagnosed before age 4 years to have been exposed to soda early, by 1 year of age (50 versus 11.11%; $p = 0.02$) (results not shown). In addition, these children had an increased likelihood of early exposure to environmental pollutants, as indicated by a higher CalEnviroScore at both birth (87.50 versus 25.81%; $p < 0.01$) (results not shown) and 9 years of age (100 versus 40.00%; $p = 0.0$) (results not shown).

Multivariate Analysis

In a multivariate model of risk factors for asthma, we did not find any significant risk factors, including any breast-feeding at age 6 months, obesity at age 2 years, a CalEnviroScore of >20 (high risk) at birth, and a mother with a high school education or fewer years of education (Table 4). Any breast-feeding at age 6 months neared statistical significance for a protective role (OR 0.47 [95% CI, 0.21–1.07]) (Table 4). In a stratified multivariate analysis by sex, any breast-feeding at 6 months of age was protective against risk of asthma for girls (OR 0.21 [95% CI, 0.05–0.86]) (results not shown) and obesity at age 2 years was associated with an increased risk (OR 12.14 [95% CI, 2.78–53.05]) (results not shown). There were no sex-specific risk factors for the boys after adjusting for confounders. Being obese at 2 years of age was not statistically significantly associated with asthma for boys (OR 0.21 [95% CI, 0.023–1.97]) (results not shown).

DISCUSSION

Incidence of Asthma

We found a high rate of asthma by 9 years of age in our HEN cohort of Latino U.S. born children (22.6%). This was much higher than that reported for

Table 1 **Characteristics of the children and risk for asthma ($N = 164$)**

Variable	Children, % (no./total no.)		OR (95% CI)	p Value
	Asthma	No Asthma		
Sex				
Girls	20.73 (17/82)	79.27 (65/82)	0.60 (0.29–1.21)	0.15
Boys	30.48 (25/82)	69.51 (57/82)	1.68 (0.82–3.42)	0.15
Obesity at				
Birth	4.88 (2/41)	1.72 (2/116)	2.92 (0.40–21.46)	0.29
6 mo	17.50 (7/40)	8.93 (10/112)	2.16 (0.64–6.85)	0.14
1 y	17.07 (7/41)	10.63 (12/113)	1.73 (0.53–5.22)	0.28
2 y	25.00 (10/40)	17.80 (21/118)	1.54 (0.65–3.63)	0.32
3 y	36.59 (15/41)	24.79 (29/117)	1.75 (0.75–3.98)	0.15
Chronic, 1–3 y	9.50 (4/42)	3.39 (4/118)	3.00 (0.72–12.58)	0.13
4 y	32.43 (12/37)	21.55 (25/116)	1.75 (0.77–3.96)	0.18
5 y	39.47 (15/38)	29.82 (34/114)	1.53 (0.71–3.30)	0.27
9 y	32.35 (11/34)	38.61 (39/101)	0.76 (0.33–1.73)	0.51
Chronic, 5 and 9 y	22.9 (8/35)	23.7 (27/114)	0.95 (0.39–2.35)	0.92
Delivery type				
Vaginal	80.95 (34/42)	89.17 (107/120)	0.52 (0.20–1.35)	0.18
Cesarean section	19.05 (8/42)	10.83 (13/120)	1.94 (0.74–5.07)	0.18
Breast-feeding				
Exclusive breast-feeding at 4–6 wk	35.71 (15/42)	51.67 (62/120)	0.52 (0.25–1.07)	0.08
Any breast-feeding at age 4–6 wk	83.33 (35/42)	93.33 (112/120)	0.36 (0.12–1.05)	0.06
Any breast-feeding at age 6 mo	47.50 (19/40)	69.49 (82/118)	0.40 (0.19–0.83)	**0.01**
Any breast-feeding at age 1 y	22.50 (9/40)	45.05 (50/111)	0.35 (0.15–0.81)	**0.01**
Sugar-sweetened beverage consumption				
Any at age 1 y	18.92 (7/37)	22.52 (25/111)	0.80 (0.31–2.04)	0.65
High consumption at age 3 y	12.20 (5/41)	6.03 (7/116)	2.16 (0.64–7.24)	0.21
High consumption at age 4 y	10.53 (4/38)	9.40 (11/117)	1.13 (0.34–3.79)	0.84
Maternal level of education				
High school education or fewer years of education	75.61 (31/41)	80.83 (97/120)	0.74 (0.32–1.71)	0.47
Environmental factors				
High risk based on CalEnviroScore at birth	40.48 (17/42)	40.00 (48/120)	1.02 (0.50–2.09)	0.96
High risk based on CalEnviroScore at age 9 y	53.12 (17/32)	63.16 (60/95)	0.66 (029–1.49)	0.32
Maternal ethnicity				
Mexican	54.76 (23/42)	62.30 (76/122)	0.73 (0.36–1.49)	0.39
Central/South American	71.43 (30/42)	72.95 (89/122)	1.36 (0.67–2.77)	0.39

OR = odds ratio; CI = confidence interval.

Mexican-American and Central American children living in California in other studies. The overall prevalence of asthma in children in California was cited at 3.1% (ages, 0–4 years) and 7.8% (ages, 5–9 years), with lower rates for Hispanics (5.8% for all children of all years).[16] However, the percentage of children with a lifetime diagnosis of asthma was found to be much higher in San Francisco County than in California as a whole for ages 5–17 years (28.2 versus 17.1%).[21] This is significantly higher than the 14.4% life-time incidence reported in 2001–2003.[12] Analysis of these statistics indicate that specific exposures are an increasing risk for children in San Francisco County.[22]

Moreover, previous reports indicate that children who lived in specific ZIP Codes, including ZIP Codes of Bayview Hunters Point and Tenderloin, where many of our participants lived, have the highest rates of hospitalization for asthma in San Francisco.[23] It is possible that our groups, based on lower socioeconomic status and who live in high environmental risk neighborhoods, have a higher risk profile for Latinos than in other areas of California. In addition, U.S. born Mexican-origin children had higher rates of asthma compared with those born in Mexico, also potentially because many U.S. Latinos lived in areas that did not meet Environmental Protection Agency's air-quality standards.[24,25]

Table 2 **Characteristics of the children and risk for asthma in boys (n = 82)**

Variable	Children, % (no./total no.)		OR (95% CI)	p Value
	Asthma	No Asthma		
Obesity at				
Birth	4.00 (1/25)	0.00 (0/54)	1.00	
6 mo	8.33 (2/24)	8.00 (4/50)	1.05 (0.18–6.15)	0.96
1 y	12.00 (3/25)	9.62 (5/52)	1.28 (0.28–5.85)	0.75
2 y	4.17 (1/24)	23.21 (13/56)	0.14 (0.02–1.09)	0.07
3 y	25.00 (6/24)	25.93 (14/54)	0.95 (0.32–2.88)	0.93
Chronic, 1–3 y	0.00 (0/25)	3.70 (2/54)	1.0	
4 y	23.81 (5/21)	26.42 (14/53)	0.87 (0.27–2.82)	0.82
5 y	36.36 (8/22)	28.85 (15/52)	1.41 (0.49–4.05)	0.52
9 y	36.84 (7/19)	46.00 (23/50)	0.68 (0.23–2.03)	0.49
Chronic, 5 and 9 y	20.0 (4/20)	25.5 (14/55)	0.73 (0.21–2.56)	0.63
Delivery type				
Vaginal	84.00 (21/25)	89.29 (50/56)	0.63 (0.16–2.46)	0.51
Cesarean section	16.00 (4/16)	10.71 (6/56)	1.59 (0.41–6.21)	0.51
Breast-feeding				
Exclusive breast-feeding at age 4–6 wk	36.00 (9/25)	53.57 (30/56)	0.49 (0.18–1.29)	0.15
Any breast-feeding at age 4–6 wk	80 (20/25)	89.29 (50/56)	0.48 (0.13–1.75)	0.27
Any breast-feeding at age 6 mo	54.17 (13/24)	70.91 (39/55)	0.48 (0.18–1.31)	0.15
Any breast-feeding at age 1 y	26.06 (6/23)	43.40 (23.53)	0.46 (0.16–1.35)	0.16
Sugar-sweetened beverage consumption				
Any at age 1 y	15.00 (3/20)	20.75 (11/53)	0.67 (0.17–2.72)	0.58
High consumption at age 3 y	12.50 (3/24)	5.66 (3/53)	2.38 (0.44–12.77)	0.31
High consumption at age 4 y	4.55 (1/22)	11.11 (6/54)	0.38 (0.04–3.36)	0.39
Maternal level of education				
High school education or less (high school diploma or less)	70.83 (17/24)	78.18 (43/55)	0.68 (0.22–2.41)	0.48
Environmental factors				
High risk based on CalEnviroScore at birth	44.00 (11/25)	33.93 (19/56)	1.53 (0.58–4.01)	0.39
High risk based on CalEnviroScore at 9 years	58.82 (10/17)	68.18 (30/44)	0.67 (0.21–2.12)	0.49
Maternal ethnicity				
Mexican	60.00 (15/25)	59.65 (34/57)	1.01 (0.39–2.65)	0.98
Central/South American	72.00 (18/25)	70.18 (40/57)	0.99 (0.38–2.57)	0.98

OR = odds ratio; CI = confidence interval.

Sex Differences

For Latina girls in our urban cohort, obesity at age 2 years increased the risk for asthma diagnosis before age 9 years. We did not find such an association in Latino boys. Previous studies with adults indicated that there is a significant sex difference in risk for asthma.[26] A nationally representative study (the Behavioral Risk Factor Surveillance System) found a stronger correlation between obesity and asthma in women than in men.[27] Furthermore, a large Canadian longitudinal study had similar findings in that obesity and asthma correlated but only in women.[28]

In studies with children similar to our study, the findings were mixed. A meta-analysis concluded that there was increased risk for boys who were overweight,[4] whereas other studies found increased risk for girls.[5–7,23] Furthermore, studies found a correlation between obesity and asthma that is independent of sex.[29] Meanwhile, prevalence studies found that asthma in prepubescent children is more common among boys and increases for girls after age 12 years.[30] Age-specific differences in risk for asthma may help explain any sex-specific differences in association between obesity and asthma.

Breast-Feeding

Previous studies found an association between breast-feeding and a reduced risk of asthma among

Table 3 **Characteristics of the children and the risk for asthma for girls (n = 82)**

Variable	Children, % (no./total no.)		OR (95% CI)	p Value
	Asthma	No Asthma		
Obesity at				
Birth	6.25 (1/16)	3.23 (2/62)	2.00 (0.17–23.56)	0.58
6 mo	31.25 (5/16)	9.68 (6/62)	4.24 (1.10–16.39)	**0.04**
1 y	25.00 (4/16)	11.48 (7/61)	2.57 (0.65–10.21)	0.18
2 y	56.25 (9/16)	12.90 (8/62)	8.68 (2.52–29.86)	**<0.01**
3 y	52.94 (9/17)	23.81 (15/63)	3.60 (1.18–10.98)	**0.02**
Chronic, 1–3 y	23.5 (4/17)	3.1 (2/64)	9.54 (1.58–57.68)	**0.01**
4 y	43.75 (7/16)	17.46 (11/63)	3.68 (1.13–13.86)	**0.03**
5 y	43.75 (7/16)	30.65 (19/62)	1.76 (0.57–5.43)	0.33
9 y	26.67 (4/15)	31.37 (16/51)	0.80 (0.22–2.88)	0.73
Chronic, 5 and 9 y	20.0 (4/20)	25.5 (14/55)	1.29 (0.35–4.72)	0.70
Delivery type				
Vaginal	76.47 (13/17)	89.06 (57/64)	0.40 (0.10–1.57)	0.19
Cesarean section	23.53 (4/17)	10.94 (7/57)	2.51 (0.64–9.84)	0.19
Breast-feeding				
Exclusive breast-feeding at age 4–6 wk	35.29 (6/17)	50.00 (32/64)	0.55 (0.15–1.86)	0.280
Any breast-feeding at age 4–6 wk	88.24 (15/17)	96.88 (62/64)	0.24 (0.02–3.67)	0.144
Any breast-feeding at age 6 mo	37.50 (6/16)	68.25 (43/63)	0.28 (0.09–0.87)	**0.03**
Any breast-feeding at age 1 y	17.65 (3/17)	46.55 (27/58)	0.25 (0.06–0.95)	**0.04**
Sugar sweetened beverage consumption				
Any at age 1 y	23.53 (4/17)	24.14 (14/58)	0.97 (0.27–3.45)	0.96
High consumption at age 3 y	11.76 (2/17)	6.35 (4/63)	1.97 (0.33–11.77)	0.46
High consumption at age 4 y	18.75 (3/16)	7.94 (5/63)	2.67 (0.36–15.67)	0.21
Maternal level of education				
High school education or fewer years of education	82.35 (14/17)	83.08 (54/65)	0.95 (0.23–3.88)	0.94
Environmental factors				
High risk based on CalEnviroScore at birth	35.29 (6/17)	45.31 (29/64)	0.66 (0.18–2.24)	0.46
High risk base on CalEnviroScore at 9 years	46.67 (7/15)	58.82 (30/51)	0.61 (0.16–2.29)	0.40
Maternal ethnicity				
Mexican	47.06 (8/17)	64.62 (42/65)	0.49 (0.17–1.43)	0.19
Central/South American	70.59 (12/17)	75.38 (49/65)	2.05 (0.70–6.05)	0.19

OR = odds ratio; CI = confidence interval.

Table 4 **Multivariate predictors of asthma (N = 136)**

Variable	OR	95% CI	p Value
Any breast-feeding at age 6 mo	0.47	0.21–1.07	0.07
Obese at age 2 y	2.23	0.86–5.76	0.10
Any sugar sweetened beverage consumption at age 1 y	0.63	0.21–1.91	0.41
CalEnviroScore of >20 at birth (by ZIP Code)	1.22	0.52–2.83	0.65
High school education or fewer years of education	0.71	0.26–1.96	0.51

OR = Odds ratio; CI = confidence interval.

diverse population groups.[31] Furthermore, for those with asthma, breast-feeding has been shown to be associated with a reduced risk for exacerbations.[14,20] The role of breast-feeding as a protective factor against asthma development in girls indicates the need to support breast-feeding in high-risk minority communities and in those with low breast-feeding rates.[32] Our study indicated that breast-feeding rates were lower among

children who had any reported asthma. Further, analysis of our results indicated that extending the time of breast-feeding by even 6 months had significant mitigating effects of the risk of asthma development in girls. Hormonal or other sex-specific biologic factor may interact with exposure to breast milk and the risk for asthma, which may explain the protective role in girls but not in boys.

Sugar-Sweetened Beverages Consumption

We found an association between early consumption of sugar-sweetened beverages and a diagnosis of asthma after age 4 years. When compared with children with asthma who were diagnosed before age 4 years, those diagnosed later in life had an earlier exposure to sugar sweetened beverage consumption. Results of studies showed a correlation between high sugar-sweetened beverages consumption and later asthma diagnosis.[32] One such study found that children from ages 2 to 9 years (a similar age group to our cohort) who consumed sugar sweetened beverages more than five times a week led to an adjusted odds of asthma that was five times greater than their counterparts who only consumed a maximum of one sugar-sweetened beverage per month (OR 5.29; $p = 0.012$).[33] However, our study was the first, to our knowledge, to indicate that sugar-sweetened beverages consumption may be related to a later asthma diagnosis, possibly through altering the risk for obesity.

Asthma and Environmental Toxins

We also found that children who currently live in high-risk environmental toxin ZIP Codes or lived in these neighborhoods at birth were diagnosed with asthma later than children in areas of less environmental risk. It is not clear why exposures to environmental toxins would be associated with a later age of diagnosis for asthma, but it is possible that these exposures may influence children who had less of a genetic risk profile for asthma development. Previous studies indicate that U.S. born Mexican-American children have a greater risk for asthma compared with foreign-born Mexicans who are living in the United States, possibly due to early environmental exposures.[29]

Limitations

Our study had a relatively small sample size, and the asthma diagnosis was based on self-report and a medical records review. We had too few mothers who reported smoking in pregnancy or exposure to secondhand tobacco smoke and too few infants who were born of low birth weight to assess these exposures on asthma diagnosis by age 9 years. Other studies that used more stringent diagnostic criteria for asthma diagnosis, such as *The International Classification of Diseases, Ninth Version* codes and specific diagnostic criteria for asthma, including spirometry testing for older children versus self-report and a medical records review, may report a lower prevalence.[34,35] Furthermore, our assessment of environmental toxin exposure was based on using the CalEnviroScreen 1.0, whereas other studies used biologic measures of toxin exposures[36,37] and may have had a better ability to describe effect sizes and specific exposures.

CONCLUSION

We found a high prevalence of asthma in our U.S. born Latino cohort of children, possibly due to environmental exposures at their place of birth in San Francisco County. Furthermore, we found sex- and age-specific risk factors for a diagnosis of asthma. Obesity may have differentially increased the risk for asthma in girls, and, similarly, breast-feeding may protect against asthma, possibly due to an interaction with hormonal factors. In addition, there may be significant differences between diagnosis before versus after the age 4 years. Early sugar-sweetened beverage and living in areas of high environmental risk may be related to a later asthma diagnosis, possibly through altering the risk for obesity.

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