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Factors Affecting Risk of the First Onset of Asthma: A Retrospective Analysis of NHANES Data 1999-2012

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Abstract

Background: Low birth weight and maternal smoking during pregnancy are associated with higher risk of asthma onset during childhood.

Aims: To evaluate the effect of gender, race/ethnicity, birth weight, and maternal smoking during pregnancy on risk of first asthma onset at the ages of 1, 2, 3-6, 7-10, and 11-15 years.

Study design: Retrospective data from national health and nutrition examination survey (NHANES) for the years 1999-2012 were analyzed. Logistic regression models were fitted to estimate the odds of first asthma onset.

Subjects: Self-reported data on 20018 children aged ≤ 15 years collected by NHANES.

Outcome measures: Age at the onset of first asthma.

Results: Male children had higher odds of ($OR \geq 1.27$) first asthma onset than female children up to the age of 10 years. Compared to non-Hispanic white children, non-Hispanic black children had higher odds of ($OR \geq 12.6$) first asthma onset up to the age of 6 years and Mexican American children had lower odds ($OR \leq 0.67$) up to the age of six years. Low birth weight (< 2500 grams) was associated with higher odds ($OR > 1.51$) of first asthma onset when the age of onset was 1 year. Maternal smoking during pregnancy was also ($OR = 1.58$) associated with higher odds ($OR > 1.51$) of first asthma onset but only when the age of onset was 1 year.

Conclusion: While, low birth weight and maternal smoking during pregnancy are risk factors for first onset of asthma, their effect may be limited to first asthma onsets during first few years of life only.

Keywords: Asthma, Smoking, Birth weight

Introduction

Asthma is a chronic disease for which there is no cure but its symptoms can be controlled with effective treatment and management [1]. Based on the analysis of data for National Health Interview Survey [2] for the year 2013, 3.5 million male and 2.6 million female children under the age of 18 years currently suffer from asthma [3] and the order of current percent prevalence of asthma by race/ethnicity among children aged < 18 years is: non-Hispanic black (13.4%) $>$ non-Hispanic white (7.5%) $>$ Hispanic (7.4%), and poverty income ratio is inversely associated with the asthma prevalence rates [4]. In 2008, children aged 5-17 years missed 10.5 million school days and currently employed adults missed 14.2 million work days due to asthma [5]. Annual cost of asthma for 2007 was estimated to be \$56 billion [6].

In a study of 1085 children with physician diagnosed asthma at the age of ≥ 2 years, exposure to carpet at home, a serious chest illness, direct exposure to father's smoking, living in a brick versus a wood home, and father being a smoker during the first two years of life were associated with a lower age of asthma onset after the age of 2 years [2]. In addition, males were approximately two times more likely to report onset of asthma between the ages of 2 and 6 years than females [7]. Sonnenschein et al. [8] conducted a meta-analysis of 147,252 children of 31 birth cohorts from Europe and reported younger gestational age at birth and higher infant weight gain to be associated with higher risk of preschool (1-4 years) wheezing and school-age (5-10 years) asthma. Odds of school-age asthma among children born preterm with high infant weight gain as compared to term-born children with normal infant weight gain was 4.47 [8]. In addition, they [8] also found that association of lower birth weight (LBW) with childhood asthma was explained by gestational age at birth. Xu et al. [9], in a meta-analysis of 1,105,703 children aged < 16 years from 13 cohort studies, however, found children born with birth weight < 2500 grams to have about 16% higher risk of developing childhood asthma than those who are born with birth weight ≥ 2500 grams.

Other studies reporting association between LBW and higher risk of asthma are by Liu et al. [10], Mu et al. [11], Kwinta et al. [12], Chang et al. [13], Brew et al. [14], Tamesis et al. [15], and Tenue et al. [16]. Base on a review article, Tedner et al. [17] suggested that rapid catch up growth later in life

rather than intrauterine growth is correlated with the development of asthma. Kallen et al. [18] reported pre-term birth to be a stronger risk factor for childhood asthma than intrauterine growth disturbances. LBW was reported to predispose adolescents to asthma development but the risk is amplified by the current excess BMI [19]. Wang et al. [20], found LBW, pre-term birth, and childhood BMI to be independent risk factors for respiratory symptoms among children; however, children with a history of LBW, pre-term birth, small for gestational age, and higher current BMI may have a higher respiratory burden. Accelerated weight gain from birth to 3 months following normal fetal growth was reported to be associated with increased risk of asthma until the age of 4 years [21]. Adjusted risk (OR) of ever and current asthma between the ages of 8 and 12 years was found to be 1.96 and 1.95 respectively among those who were born pre-term and 1.88 and 2.05 respectively among those who were born with LBW [22]. However, in a study of retrospective birth cohort of children born between January 1, 1976 and December 31, 1979 in Rochester, Minnesota, USA, birth weight <2500 grams was not found to be associated with risk of asthma during the first six years of life [23]. Among children <5 years of age, risk of developing asthma decreased by 5.5% and 7.9% for each additional week of gestation among children without and with any lower respiratory tract infection, respectively [24].

Willeboordse et al. [25] reported positive association between asthma and body mass index (BMI) among girls but not boys. Rapid growth in BMI during the first two years was reported to be associated with increased risk of asthma among children <6 years of age [26]. Respiratory infection before the age of 1 year was found to be positively associated with the risk of asthma after the age of 5 years and the association was stronger among those who were born with a gestational age of <28 weeks [27].

Neuman et al. [28] reported a positive association between maternal smoking during pregnancy and development of wheezing (OR=1.39) and asthma (OR=1.65) at the age of 4 to 6 years and there was a positive dose dependent relationship between wheezing and asthma and number of cigarettes smoked during the first trimester of pregnancy. In utero exposure to maternal smoking was associated with an increased risk of asthma (OR=1.67 for age <5 years, OR=1.49 for age >5 years) [29]. In addition, current exposure to household environmental tobacco smoke (ETS) was associated with increased prevalence of ever asthma, active asthma, and bronchitis and children with ≥ 3 household smokers had a higher risk of early-onset asthma [30]. In a study of 5951 children aged 8-12 years from Russia, maternal smoking during pregnancy was found to have a strong consistent effect on risk of diagnosed asthma (OR=2.46) but the current exposure to ETS was not found to affect the risk of asthma [22]. In a study of adults aged 21-63 years, adjusted odds of asthmatics as compared to non-asthmatics having exposure to ETS at work was 2.16 and having exposure to ETS at home was 4.77 [30]. Based on the meta-analysis of 14 case-control studies, pooled odds of asthma prevalence among children up to the age of 6 years exposed to ETS from either parent was reported to be

1.37 [31]. In a matched case-control study conducted among 12-14 year old school children in Taiwan, childhood asthma was found to be associated with early life exposures to cockroaches, visible mold, carpet, and more than one hour of exposure to ETS per day (OR=1.93) [32]. The adjusted attributable fraction of adult incidence of asthma caused by maternal smoking was reported to be 17.3% and 9.3% caused by maternal smoking and by other household members respectively [33]. Girls whose mothers smoked ≥ 20 cigarettes per day during pregnancy and at 6-month follow up had increased odds (OR=1.96) of asthma experiencing symptoms at the age of 14 years but this association was not observed among boys, and in addition, contribution of smoking during pregnancy was stronger than after the birth [34]. In never-smoker adults aged 15-69 years with childhood exposure to ETS, prevalence of asthma was reported to be 7.6% versus 5.9% among non-exposed adults [35]

To the best of our knowledge, no study has evaluated how the association of asthma varies with LBW, maternal smoking, gender, and race/ethnicity with different ages among children at which the first onset of asthma is observed. For example, does the association between asthma and LBW decrease, increase, or remains the same when the first onset of asthma is observed at the age of 1 year vs. the first onset of asthma is observed at the age of 5 years. Consequently, this study was undertaken to evaluate how the association of asthma varies with LBW, maternal smoking, gender, and race/ethnicity when the age at which first onset of asthma is observed is 1, 2, 3-6, 7-10, and 11-15 years. Data from National Health and Nutrition Examination Survey (NHANES) [36] for the years 1999-2012 were selected for this purpose. Details are given in the next section.

Methods

Early childhood questionnaire [37] administered in NHANES provides retrospective data on birth weight, maternal smoking status during pregnancy, and mother's age at the time of birth for children aged ≤ 15 years. Data are reported by the person acting as the spokesperson for the household selected to participate in NHANES and as such, are subject to recall bias. Medical conditions questionnaire [38] used in NHANES asks several asthma related questions, for example, (i) if a doctor or health professional ever told participant having asthma, and if yes, (ii) how old was the participant when (s)he first had asthma, and (iii) does the participant still has asthma, and if so, (iv) did the participant have asthma attack during the past 12 months and (v) if this asthma attack resulted in an emergency care visit. Data from these two questionnaires in combination with other NHANES data were used to construct the database for this study.

Consequently, data from NHANES [36] for the years 1999-2012 from demographic, early childhood questionnaire, body measures, family smoking questionnaire, medical conditions questionnaire, and housing characteristics questionnaire files were downloaded and match merged for children aged 15 years and younger. The sampling plan for NHANES is a complex, stratified, multistage, probability cluster

designed to be representative of the civilian, non-institutionalized U.S. population. Data from demographic files on current age, gender (male, female), race/ethnicity (non-Hispanic white or NHW, non-Hispanic black or NHB, Mexican American or MA, other unclassified race/ethnicities or OTH), current poverty income ratio (PIR), and on current body mass index (BMI) from body measures were selected for the analysis. From early childhood questionnaire, data as reported by the guardian/parent of the children aged ≤ 15 years on mother's smoking status during pregnancy (yes, no), mother's age at birth (M_Age), and birth weight (< 2500 grams, ≥ 2500 grams) were selected for analysis. From medical questionnaire, data on ever onset of asthma (yes, no), age of the first onset of asthma (FOAS), and current asthma status (yes, no) were selected for analysis. Based on the age of FOAS, data were divided in five groups, namely, those who had age of FOAS at 1 year of age, those who had age of FOAS at 2 years of age, those who had age of FOAs between 3 and 6 years of age, those who had age of FOAS between 7 and 10 years of age, and those who had age of FOAS between the ages of 11 and 15 years. Family smoking questionnaire provided data on exposure to ETS at home (yes, no) and housing characteristics questionnaire provided data on residential housing status (owned, rented, other arrangements).

Logistic regression models were fitted to estimate the odds of asthma onset for each of the five FOAS groups. For each of these five models, called full models, independent variables included in the models were: gender, race/ethnicity, birth weight, mother's smoking status during pregnancy, and mother's age at birth. Since, data on PIR, BMI, SHS exposure, and residential housing status were not available at the time of asthma onset; these variables were not included in the above mentioned full models. However, assuming PIR, BMI, SHS exposure, and residential housing status remain stable for up to three years, those for whom the difference between the current age and the age at FOAS was ≤ 3 years, another set of five logistic regression models, called reduced models, were fitted for these downsized FOAS groups. For this second set of five models, PIR, BMI, SHS exposure, and residential housing status were also included in the models as independent variables. A total of 20018 participants were available for analysis. However, because of missing values for one or more independent variables, sample sizes used in regression models were smaller. Actual sample sizes used for these two sets of models are given in **Table 1**.

Table 1 Unweighted sample sizes used in logistic regression models by age of first asthma onset, gender, race/ethnicity, birth weight, secondhand smoke exposure, residential living status. Data from National Health and Nutrition Examination Survey 1999-2012.

Dataset		Age of first asthma onset in years									
		1		2		3-6		7-10		11-15	
		N	%	N	%	N	%	N	%	N	%
	Total	18105	100.0	17219	100.0	15958	100.0	10925	100.0	6404	100.0
	Asthma	1300	7.2	414	2.4	833	5.2	400	3.7	184	2.9
	No Asthma	16805	92.8	16805	97.6	15125	94.8	10525	96.3	6220	97.1
	Male	8981	49.6	8437	49.0	7853	49.2	5318	48.7	3078	48.1
	Female	9124	50.4	8782	51.0	8105	50.8	5607	51.3	3326	51.9
Full	Non-Hispanic White	5023	27.7	4860	28.2	4464	28.0	2994	27.4	1734	27.1
	Non-Hispanic Black	5003	27.6	4620	26.8	4349	27.3	3033	27.8	1817	28.4
	Mexican American	5580	30.8	5406	31.4	4983	31.2	3526	32.3	2116	33.0
	Other	2499	13.8	2333	13.5	2162	13.5	1372	12.6	737	11.5
	Smoker	2426	13.4	2234	13.0	2091	13.1	1447	13.2	854	13.3
	Nonsmoker	15679	86.6	14985	87.0	13867	86.9	9478	86.8	5550	86.7
	< 2500 grams	1735	9.6	1593	9.3	1479	9.3	996	9.1	591	9.2
	≥ 2500 grams	16370	90.4	15626	90.7	14479	90.7	9929	90.9	5813	90.8
Reduced	Total	17053	100.0	16777	100.0	15268	100.0	10624	100.0	6335	100.0
	Asthma	419	2.5	143	0.9	299	2.0	198	1.9	170	2.7
	No Asthma	16634	97.5	16634	99.1	14969	98.0	10426	98.1	6165	97.3
	Male	8365	49.1	8203	48.9	7467	48.9	5163	48.6	3040	48.0

Female	8688	50.9	8574	51.1	7801	51.1	5461	51.4	3295	52.0
Non-Hispanic White	4799	28.1	4745	28.3	4280	28.0	2913	27.4	1721	27.2
Non-Hispanic Black	4589	26.9	4462	26.6	4116	27.0	2937	27.6	1795	28.3
Mexican American	5329	31.2	5284	31.5	4816	31.5	3430	32.3	2090	33.0
Other	2336	13.7	2286	13.6	2056	13.5	1344	12.7	733	11.6
Smoker	2230	13.1	2168	12.9	1985	13.0	1402	13.2	847	13.4
Nonsmoker	14823	86.9	14609	87.1	13283	87.0	9222	86.8	5488	86.6
< 2500 grams	1592	9.3	1538	9.2	1409	9.2	969	9.1	585	9.2
>= 2500 grams	15461	90.7	15239	90.8	13859	90.8	9655	90.9	5750	90.8
SHS Exposure	2933	17.2	2874	17.1	2664	17.4	1921	18.1	1184	18.7
No SHS Exposure	14120	82.8	13903	82.9	12604	82.6	8703	81.9	5151	81.3
Owned	9107	53.4	9007	53.7	8330	54.6	6048	56.9	3711	58.6
Rented	7685	45.1	7515	44.8	6711	44.0	4432	41.7	2536	40.0
Other Arrangement	261	1.5	255	1.5	227	1.5	144	1.4	88	1.4

All data were analyzed by SAS v. 9.3 [38]. Specifically Proc SURVEYMEANS was used to do the univariate analyses and Proc SURVEYLOGISTIC was used to do logistic regression analysis.

Results

Univariate analysis

Ever asthma prevalence was found to be 15.4%. Males had higher prevalence than females (**Table 2**). MA had the lowest prevalence rate and NHB the highest (11.3% vs. 20.9%). Mother's smoking during pregnancy was associated with

increased ever asthma prevalence rates. Those born with birth weight <2500 grams had prevalence rates that were higher than for those who were born with birth weight >=2500 grams (18.7% vs. 15.1%).

During the past year, 6% children had an asthma attack and 32% of these went to emergency room (ER) to get treatment for asthma (**Table 2**). The order in which prevalence of asthma attack during the past year by race/ethnicity was observed was NHB>OTH>NHW>MA. In addition, 48.6% NHB children went to ER to get the treatment for asthma attack (**Table 2**). Also, 42.5% of those who were born with birth weight <2500 grams and had an asthma attack last year also went to ER for asthma treatment.

Table 2 Percent prevalence of ever and current asthma attack (past year) by gender, race/ethnicity, mother's smoking during pregnancy, and birth weight. Data from National Health and Nutrition Examination Survey 1999-2012.

		Ever Asthma	Asthma Attack Last Year	Emergency Visit *
Total	Total	15.4 (14.5-16.3)	6 (5.5-6.5)	32 (28.6-35.4)
Gender	Male	17.6 (16.2-18.9)	7 (6.2-7.8)	35.7 (31.6-39.9)
	Female	13.1 (12.2-14)	5 (4.4-5.5)	26.6 (21.3-31.9)
Race/Ethnicity	Non-Hispanic White (NHW)	14.5 (13.2-15.8)	5.8 (5.1-6.5)	23.8 (20-27.6)
	Non-Hispanic Black (NHB)	20.9 (19.4-22.5)	8.6 (7.6-9.5)	48.6 (43.4-53.9)
	Mexican American (MA)	11.3 (10.3-12.3)	3.7 (3.2-4.3)	35.9 (31.9-39.9)
	Other (OTH)	17.6 (15.6-19.5)	6.5 (5.3-7.8)	37.8 (32.4-43.2)
Smoking status during pregnancy	Smoker	17.9 (15.6-20.1)	6.5 (5.4-7.6)	28.5 (21.9-35)
	Nonsmoker	14.9 (14-15.8)	5.9 (5.4-6.4)	32.8 (29.2-36.4)
Birth Weight	<2500 grams	18.7 (16.2-21.1)	7 (5.5-8.5)	42.5 (36.2-48.8)
	>=2500 grams	15.1 (14.2-16)	5.9 (5.5-6.4)	30.8 (27.3-34.4)

*Of those who had asthma attack during the last 12 months.

Logistic regression analysis

Effect of gender and race/ethnicity

Irrespective of the model fitted, male children had statistically significantly higher odds of a first asthma onset than female children when the age of first asthma onset was up to 10 years (OR: 1.27 to 1.65, **Table 3**) and odds were lower at the age of 7-10 years than they were at the age of 1 year (1.27 vs. 1.65 for the full model). As compared to NHW, NHB children had statistically significantly higher odds of a first asthma onset when the age of first asthma onset was up to 6 years (OR: 1.26 to 2.06, **Table 3**) for the full model and when

the age of FOAS was 1 year for reduced model (OR=1.64, **Table 3**). As compared to NHW, MA children had statistically significantly lower odds of a first asthma onset when the age of first asthma onset was up to 6 years (OR: 0.65 to 0.81, **Table 3**) for the full model and when age of FOAS was 1 or 2 years for reduced model (OR<=0.65, **Table 3**). In addition, odds of first asthma onset showed a decreasing trend as the age of first asthma onset increased (**Table 3**). For example, for the full model for NHB as compared to NHW, odds of first asthma onset dropped from 2.06 for age=1 year to 1.26 when the age was between 3 and 6 years (**Table 3**).

Table 3 Adjusted odd ratios of first asthma attack at specified ages with 95% confidence intervals by gender, race/ethnicity, mother's smoking status during pregnancy, birth weight, secondhand smoke exposure, and living arrangements. Data from National Health and Nutrition Examination Survey 1999-2012.

		Age of First Asthma Attack in Years				
		1	2*	3-6**	7-10***	11-15****
Full Model						
Gender	Male s. Female	1.65 (1.48-1.84)	1.53 (1.24-1.87)	1.44 (1.26-1.66)	1.27 (1.06-1.51)	0.87 (0.66-1.15)
Race/Ethnicity						
Non-Hispanic Black (NHB) vs. Non-Hispanic White (NHW)	NHB vs. NHW	2.06 (1.7-2.49)	1.53 (1.15-2.03)	1.26 (1.02-1.54)	1.16 (0.91-1.48)	0.85 (0.58-1.23)
Mexican American (MA) vs. Non-Hispanic White (NHW)	MA vs. NHW	0.86 (0.69-1.08)	0.65 (0.47-0.9)	0.67 (0.55-0.81)	0.85 (0.66-1.1)	0.79 (0.5-1.25)
Unclassified Race/Ethnicities (OTH) vs. Non-Hispanic White (NHW)	OTH vs. NHW	1.81 (1.41-2.33)	1.16 (0.85-1.6)	1.3 (1.02-1.65)	1.14 (0.81-1.61)	1.07 (0.64-1.79)
Mother's smoking status during pregnancy	Smoker vs. Nonsmoker	1.58 (1.35-1.84)	1.11 (0.83-1.49)	1.12 (0.9-1.38)	1.41 (1.09-1.82)	0.96 (0.6-1.53)
Birth Weight	< 2500 grams vs. >=2500 grams	1.56 (1.32-1.83)	1.31 (0.98-1.76)	1.09 (0.87-1.36)	0.71 (0.48-1.05)	1.51 (0.97-2.33)
Reduced Model[^]						
Gender	Male s. Female	1.51 (1.24-1.83)	1.58 (1.1-2.26)	1.34 (1.07-1.7)	1.41 (1.1-1.81)	0.86 (0.65-1.15)
Race/Ethnicity						
Non-Hispanic Black (NHB) vs. Non-Hispanic White (NHW)	NHB vs. NHW	1.64 (1.21-2.22)	1.21 (0.78-1.85)	1.15 (0.78-1.68)	1.35 (0.9-2)	0.74 (0.5-1.09)
Mexican American (MA) vs. Non-Hispanic White (NHW)	MA vs. NHW	0.55 (0.37-0.81)	0.54 (0.32-0.91)	0.69 (0.45-1.05)	0.88 (0.55-1.4)	0.68 (0.38-1.22)
Unclassified Race/Ethnicities (OTH) vs. Non-Hispanic White (NHW)	OTH vs. NHW	1.43 (1.01-2.01)	1.23 (0.76-2.0)	1.1 (0.7-1.73)	1.5 (0.94-2.39)	0.94 (0.55-1.61)

Mother's smoking status during pregnancy	Smoker vs. Nonsmoker	1.59 (1.18-2.15)	1.1 (0.68-1.79)	1.09 (0.74-1.6)	1.75 (1.23-2.48)	1.01 (0.59-1.74)
Birth Weight	< 2500 grams vs. \geq 2500 grams	1.51 (1.1-2.08)	1.02 (0.57-1.84)	1.11 (0.77-1.6)	0.62 (0.34-1.14)	1.51 (0.94-2.42)
Secondhand smoke exposure at Home	Yes vs. No	0.8 (0.62-1.04)	1 (0.63-1.57)	0.94 (0.67-1.33)	0.62 (0.43-0.91)	0.82 (0.55-1.22)
Living Arrangement	Rented vs. Owned	1.16 (0.88-1.52)	1.9 (1.22-2.96)	1.09 (0.81-1.47)	0.99 (0.68-1.43)	1.07 (0.76-1.51)
	Other arrangements vs. Owned	1.12 (0.5-2.5)	0.63 (0.09-4.39)	1.97 (0.95-4.05)	1.59 (0.58-4.4)	0.9 (0.22-3.67)

[^] Respondents for whom difference between current age and age at asthma was 3 years old were excluded from the analysis. *Included only those non-asthmatics who were at least 2 years old. **Included only those non-asthmatics who were at least 3 years old. ***Included only those non-asthmatics who were at least 7 years old. ****Included only those non-asthmatics who were at least 11 years old.

Effect of birth weight and maternal smoking during pregnancy

Mother's smoking during pregnancy was associated with statistically higher odds of a first asthma onset when the age of first asthma onset was 1 year (OR \leq 1.59, **Table 3**). Birth weight <2500 grams was associated with statistically higher odds of a first asthma onset when the age of first asthma onset was 1 year (OR \leq 1.56, **Table 3**).

Effect of exposure to ETS and residential living style

Exposure to SHS at home was not found to be associated with the probability of an asthma onset. Renting compared to owning a house was associated with higher odds of an asthma onset at the age of two years (OR=1.9, **Table 3**).

Effect of PIR, BMI, and mother's age at birth

PIR was negatively associated with first onset of asthma when the age of FOAS was 1 year (β = -0.1665, p <0.01). For a

unit change in PIR, odds of an asthma onset decreased to 0.85. Mother's age at birth was not associated with the first onset of asthma except when the first onset of asthma was between the ages of 3 and 6 years (β =0.0274, p <0.01, **Table 4**). In the latter case, mother's age at birth was associated with increased odds of an asthma onset (OR: 1.03). When the age of FOAS was 1 year, one additional room in the house was associated with decrease in the probability of an asthma onset (β =-0.0992, p <0.01, OR=0.91, **Table 4**). When the age of FOAS was up to 3 years, BMI was found to be negatively associated with the probability of a first asthma onset. For a unit change in BMI, the odds of an asthma onset decreased to 0.84 when the age of FOAS was 1 or 2 years and to 0.92 when the age of FOAS was 3-6 years (**Table 4**). However, when the age of FOAS was 11-15 years, BMI was found to be positively associated with the probability of a first asthma onset. For a unit change in BMI, the odds of an asthma onset increased to 1.05 when the age of FOAS was 11-15 years (**Table 4**).

Table 4 Adjusted slopes[^] (β) with standard errors (SE) and p-values for poverty income ratio (PIR), mother's age at birth (M Age), current body mass index (BMI), and number of rooms in the house. Data from National Health and Nutrition Examination Survey 1999-2012.

Age of First Asthma Attack in Years	Independent Variable	β	SE	p	R ² in percent	Odds Ratio for a unit change in independent variable
1	PIR	-0.1665	0.0491	<0.01	9.1	0.85 (0.77-0.93)
	M Age	-0.0144	0.0080	0.07		0.99 (0.97-1)
	BMI	-0.1735	0.0144	<0.01		0.84 (0.82-0.86)
	Rooms	-0.0992	0.0298	<0.01		0.91 (0.85-0.96)
2*	PIR	-0.0775	0.0668	0.25	5.9	0.93 (0.81-1.05)
	M Age	0.0269	0.0142	0.06		1.03 (1-1.06)
	BMI	-0.1719	0.0286	<0.01		0.84 (0.8-0.89)
	Rooms	0.0151	0.0517	0.77		1.02 (0.92-1.12)
3-6**	PIR	-0.0369	0.0454	0.42	2.5	0.96 (0.88-1.05)
	M Age	0.0274	0.0105	0.01		1.03 (1.01-1.05)

	BMI	-0.0835	0.0190	<0.01		0.92 (0.89-0.95)
	Rooms	-0.0202	0.0363	0.58		0.98 (0.91-1.05)
7-10***	PIR	0.0004	0.0604	0.99	1.5	1 (0.89-1.13)
	M Age	-0.0105	0.0118	0.37		0.99 (0.97-1.01)
	BMI	0.0142	0.0144	0.32		1.01 (0.99-1.04)
	Rooms	0.0354	0.0418	0.40		1.04 (0.95-1.12)
11-15****	PIR	-0.0113	0.0610	0.85	1.6	0.99 (0.88-1.11)
	M Age	-0.0027	0.0160	0.87		1 (0.97-1.03)
	BMI	0.0512	0.0125	<0.01		1.05 (1.03-1.08)
	Rooms	0.0107	0.0451	0.81		1.01 (0.93-1.1)

[^]Respondents for whom difference between current age and age at asthma was > 3 years old were excluded from the analysis. *Included only those non-asthmatics who were at least 2 years old. **Included only those non-asthmatics who were at least 3 years old. ***Included only those non-asthmatics who were at least 7 years old. ****Included only those non-asthmatics who were at least 11 years old

Discussion

LBW was found to be a risk factor for first asthma onset as has been documented in other studies [9-20]. However, based on the analysis of NHANES data for this study, when adjustments are made for other factors that affect the risk of asthma onset, LBW ceases to be a risk factor for onset of first asthma onset beyond the age of 1 year. As has been suggested in some studies [8,18,19], relatively rapid catch-up growth after birth and pre-term birth or small for gestational age may be overriding risk factors for onset of asthma. No data on gestational age and rate of growth after birth were available in NHANES and as such they could not be included in the analysis.

Maternal smoking during pregnancy was found to be a risk factor for onset of asthma for the ages of 1 and 7-10 years. These results are concurrence with other studies [28,29]. However, it is unknown why maternal smoking during pregnancy was not found to be a risk factor for the asthma onset at other ages. Neuman et al. [28] found maternal smoking to be a risk factor for asthma at the ages of 4-6 years but their study was based on several birth cohorts and may not have reported data on first onset of asthma.

Male gender was found to be a higher risk factor for first onset of asthma up to the age of ten years but level of risk associated with male gender may be on decline with increase in age of first asthma onset. Ferry et al. [7] also found male gender to be a higher risk factor for asthma onset. Beyond the age of 10 years, male gender ceased to be a risk factor for asthma onset.

While data on prevalence of current and/or life-time asthma by race/ethnicity are produced by the Centers for Disease Control [3], we could not find another recent NHANES study that has published data on relative risk of first time asthma onset associated with different racial/ethnic groups in US. As compared to NHW, NHB had higher risk of first time asthma onset until the age 6 years but the risk was found to decline with increase in the age of first asthma onset.

Exposure to ETS was found to be a risk factor for asthma onset in several studies [29-33,35] but not so in another study [22]. In this study, exposure to ETS as measured within three years from the age of first asthma onset was not found to affect risk of first asthma onset. NHANES did not provide data on ETS exposure at the same time or before the asthma onset was reported. Some of the studies that reported ETS exposure as a risk factor for asthma onset was based on ETS exposure prior to asthma onset, not after the asthma onset. That is probably the reason why ETS exposure was not found to affect risk of asthma onset in this study. Renting vs. owning a house was found to be associated with higher risk of asthma onset at the age of 2 years which may be because the living environment in rented housing may expose residents to environmental contaminants including but not limited to ETS which are associated with enhanced risk of asthma onset.

Excess BMI concurrent with the onset of asthma have been reported to increase the risk of asthma [19,20,25,26]. For this study, since BMI concurrent with the asthma was not available, BMI within 3 years post-asthma onset was used. When the age of first asthma onset was between 11 and 15 years, BMI was found to enhance the risk of first asthma onset. However, when the age of first asthma onset was between 1 to 6 years old, BMI was negatively associated with the odds of having asthma onset. The reason for this unexpected finding is unknown but the use of BMI post-asthma onset may be the reason.

The results of this study should be viewed with caution because of non-availability of data on gestational age, growth rate after birth, and BMI and ETS exposure concurrent with the age at asthma onset. In addition, recall bias may have affected the quality of data.

In conclusion, (i) LBW is associated with increased risk of asthma onset at the age of 1 year, (ii) maternal smoking during pregnancy was associated with increased risk of asthma onset at the age of 1 and 7-10 years, (iii) male gender was associated with enhanced risk of asthma onset up to the age of 10 years but the magnitude of risk declined with increase in the age of

the asthma onset, and (iv) NHB children had higher risk of asthma onset than NHW children up to the age of 6 years.

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