

ORIGINAL ARTICLE

Childhood Asthma Prevalence in Northern Puerto Rico, the Rio Grande, and Loíza Experience

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Objective. Childhood asthma is highly prevalent in some areas of Puerto Rico. The objective of this study was to estimate the prevalence of asthma in two municipalities of Northern Puerto Rico. **Methods.** Children 6 to 7 and 13 to 14 years of age participated in the school-based cross-sectional study. **Results.** A total of 1,467 elementary school students and 1,334 junior-high school students were included in the survey. A high prevalence of asthma was observed; 46% in elementary schools and 24% in junior-high schools. In elementary schools, family history of asthma (FHA) was associated with ever wheezed (PR = 2.00, 95%CI 1.59, 2.52), wheeze during last year (PR = 2.02, 95%CI 1.54, 2.62), and asthma (PR = 2.33, 95%CI 1.86, 2.92). For junior-high schools FHA was associated with ever wheezed (PR = 2.01, 95%CI 1.56, 2.57), wheeze during previous year (PR = 2.00, 95%CI 1.47, 2.73), and asthma (PR = 2.72, 95%CI 2.06, 3.60). **Conclusions.** This study showed a high prevalence of asthma and related symptoms in Northern Puerto Rico. FHA was strongly associated with asthma and its symptoms. Further research is recommended to look at genetics, sensitivity levels, indoor and outdoor pollution, and gene-environment interactions.

Keywords prevalence, childhood asthma, wheezing illness, family history, Puerto Rico

INTRODUCTION

Asthma is a chronic disease that affects people in all age groups. In the United States, the cost related to asthma was estimated at 12.7 billion dollars annually (1). The self-reported asthma prevalence increased by approximately 74% from 1980 to 1996, with an estimated 14.6 million persons (54.6 per 1,000) reporting asthma during the previous 12 months by 1996 (2). In 1997, the prevalence was estimated as 40.7 per 1,000; but this decrease in the estimate may possibly be related to the change in the design of the National Health Interview Survey. Data from the Centers for Disease Control and Prevention (CDC) show that the rates for asthma attacks, during the previous 12 months, in children younger than 17 years of age was 4.9 per 100 for the period of 2000 to 2004 (3). However, children from minority groups are more affected by the disease, and in the U.S. children of Puerto Rican descent present the highest estimates (4–10).

Table 1 presents asthma estimates for different ethnic groups in the U.S. and Puerto Rico. Carter-Pokras et al. (4) found that Puerto Rican children who lived in the continental U.S. had the highest lifetime prevalence compared with non-Hispanic white, non-Hispanic blacks, Mexican-Americans, and Cubans. Similar findings were observed by Beckett et al.

(6) in Connecticut and Crain et al. (5) in New York City. Prevalence estimates for Puerto Rican children in the U.S. vary from 18% to 35% (Table 1). Furthermore, Puerto Rican children living in the Island present rates that are much higher than the rates observed in the continental U.S. Perez-Perdomo et al. (9) asked parents in Puerto Rico about asthma diagnosis in their children and found that about 33% of the parents reported asthma in any of their children. Similar estimates are reported by Nazario et al. (10) in a survey conducted with school-aged children in San Juan—about 39% of private school students and 43% of public school children reported that they have been told by a physician they have asthma (Table 1). Asthma attacks that require hospital admission may also be common in the Island. Mayol et al. (11) found that in the San Pablo Hospital in Bayamón, asthma admissions represented 29% of the total admissions (11); Montealegre et al. (12) studied asthma emergency room visits in southern Puerto Rico (Ponce) and found that about 45% of the visits were from children 1 to 9 years of age (12).

In 1996, the Puerto Rico Department of Health (PRDOH) made public the results of the “Cataño Air Basin (CAB) Study” (CABS) (13, 14). This study was conducted to estimate the asthma prevalence rate in the CAB, which is known for its industrial air pollution problems. A secondary objective was to compare that prevalence rate with the asthma prevalence in a control area that did not have the air pollution problems. Two municipalities comprised the control area: Rio Grande and Loíza, located in northern Puerto Rico. The CABS provided the opportunity to explore asthma occurrence in Puerto Rico and its risk factors including air

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TABLE 1.—Estimates for asthma prevalence by ethnic group in the United States and Puerto Rico.

Source	Age (years)	Location	Ethnic group	Lifetime prevalence (%)
Carter-Pokras et al., 1993 (4)	6-months to 11 years old	New York City Miami	Mainland Puerto Ricans	20.1
			Mexicans	4.5
			Cubans	8.8
			Non-Hispanic Blacks	9.1
			Non-Hispanic White	6.4
Crain et al., 1994 (5)	0 to 17	New York City	Hispanic*	17.9
			Black	11.6
			White	8.2
Beckett et al., 1996 (6)	—	Connecticut	Hispanic*	18.4
			Black	11.3
			White	7.4
Perez-Perdomo et al., 2003 (9)	—	Puerto Rico (PR)	Island Puerto Ricans	33.2 [†]
Findley et al., 2003 (8)	5 to 12	Eastern Harlem	Puerto Ricans	35.0 [‡]
Nazario et al., 2004 (10)	4 to 7	San Juan, PR	Island Puerto Ricans	
			Public schools	43.2
			Private schools	39.4

*Mostly mainland Puerto Ricans.

[†]Parents reported asthma diagnosis in any of their children.[‡]Asthma defined as doctor or nurse diagnosis at any time plus wheezing in the past 12 months.

pollution. However, the evaluation of children from the control area provided valuable insight on the asthma experience in Northern Puerto Rico and the possibility to identify risk factors other than outdoor air pollution. This article presents the analysis conducted with the data from the control area.

This study was conducted to estimate the prevalence of wheezing illness and asthma and to describe the severity and characteristics of wheezing illness in children 6 to 7 and 13 to 14 years of age residing in the Rio Grande and Loíza municipalities in northeast Puerto Rico.

MATERIALS AND METHODS

Study Design

The prevalence of asthma and wheezing illness in children residing in Rio Grande and Loíza was estimated with a cross-sectional school-based study. All the public and private schools located in these two municipalities were included: 19 public and 4 private elementary schools, and 6 public and 3 private junior-high schools participated. Eligible participants were children 6 to 7 years of age and 13 to 14 years of age old who were enrolled in the public and private schools of the area. The study protocol was evaluated and cleared by the Institutional Review Board (IRB) at the PRDOH.

The protocol from the "International Study of Allergies and Asthma in Childhood" (ISAAC) was followed to determine the ages to be included and study implementation procedures. The data collection instrument was a self-administered questionnaire prepared following the standardized form recommended in ISAAC (15). The ISAAC involved a multinational collaboration of investigators whose purpose was to develop standardized epidemiologic approaches to identify asthma that allowed meaningful geographic and temporal comparisons. The questionnaire was translated into Spanish in Mexico, modified for use in Puerto Rico, and tested in the pilot phase of the CABS. Two types of questionnaires were produced: one for the parents of the 6- to 7-year-old children and another for the 13- to 14-year-old participants.

The consent forms and questionnaires were sent home to be completed by the parents of elementary school children.

Teachers were asked to start collecting the questionnaires 1 week later. Then, 2 weeks after questionnaire distribution a study staff member visited the schools to collect the questionnaires that had been returned. In schools with low participation rates, follow-up was conducted with the parents by telephone. Schools with few questionnaires were visited once more in an attempt to improve participation. For the junior-high schools, the consent forms were sent to the parents; later the questionnaire was administered in the classroom to the students who returned a signed consent form. Similarly to the elementary schools, those with low participation rates were visited once more to get more questionnaires administered to any student who may have returned the signed consent form later. The data collection was conducted over a 8-month period, starting in October 1994 through May 1995.

Asthma lifetime diagnosis was determined by an affirmative response from the parents to the question *Has your child ever been told by a physician or other health professional that he/she has asthma?* For the junior-high students the question was rephrased as *Have you ever been told by a physician or other health professional that you have asthma?* Similar questions were asked to determine the diagnosis of bronchial asthma and wheezing illness. Data were also collected on the following severity measurements: ever had a wheezing attack that required emergency room visit; and questions on severity during the previous year included the number of wheezing attacks, number of times their sleep was disturbed by wheezing attacks, the number of times their speech was limited by wheezing attacks, wheezing attacks after exercise and if they had wheezing attacks apart from colds. Finally, the presence of a smoker in the house was determined by an affirmative response to *Does anyone smoke in your home?*

Statistical Procedures

The prevalence of asthma and wheezing illness was estimated using as denominator the number of participants who provided valid information; missing values and "Don't know" were excluded from the calculation. Prevalence ratios were estimated by demographic variables for wheezing illness, asthma, and bronchial asthma. Univariate logistic regression

TABLE 2.—Prevalence estimates* for study variables in elementary and junior-high schools: Rio Grande and Loíza, Puerto Rico.

	Schools			
	Elementary (n = 1,467)		Junior (n = 1,334)	
	%	95%CI	%	95%CI
Smoker in household	31.1	28.6, 33.6	29.9	27.4, 32.5
Family history of asthma	58.3	55.6, 61.0	50.4	47.3, 53.4
Lifetime asthma diagnosis	46.1	43.4, 48.8	24.1	21.8, 26.5
Lifetime bronchial asthma diagnosis	21.8	19.6, 24.1	8.2	6.8, 9.9
Ever wheezed	46.7	44.0, 49.2	33.8	31.2, 36.4
Ever had wheezing attack that required ER visit	31.5	21.1, 34.0	11.3	9.7, 13.2
Wheezing attacks previous year	29.1	26.6, 31.6	19.9	17.8, 22.2
<i>Severity measures for children with attacks during the previous year</i>	<i>Elementary schools (n = 378)</i>		<i>Junior-high schools (n = 257)</i>	
>3 wheezing attacks previous year	24.9	20.6, 29.6	29.9	24.3, 36.0
≥ Once/week night waking by wheezing attacks previous year	31.5	26.8, 36.4	43.2	35.9, 50.7
Speech limited by wheezing attacks previous year	36.6	31.9, 41.6	40.0	33.9, 46.4
Wheezing attacks after exercise previous year	48.4	43.3, 53.6	60.2	53.9, 66.2
Wheezing attacks without a cold previous year	38.3	33.4, 43.3	46.6	40.3, 53.0

*Estimates are based on the number of forms with an answer to each particular question, missing values and *don't know* were excluded, 95% CI: 95% confidence interval.

was used to obtain the prevalence ratios. The 95% confidence intervals for the prevalence ratios and the Pearson's chi-square *p* value were used to test significance.

RESULTS

Elementary Schools

A total of 1,467 questionnaires were returned by the parents of the 6- to 7-year-old children, yielding a 64% participation rate. Table 2 presents the prevalence estimates: wheezing illness and asthma were highly prevalent; ever wheezed was reported by nearly 47%, a similar proportion reported asthma diagnosis (46%), and nearly 32% of the children had a wheezing attack that required a visit to the emergency room (ER). For those that had wheezing attacks during the previous year, about 25% had more than 3 wheezing attacks, 31% reported that their child's sleep was interrupted by wheezing attacks more than once per week, 38% had wheezing attacks without a cold and 48% had the attacks after exercise. Family history of asthma and a smoker in the house were highly prevalent too, 58% and 31%, respectively.

Table 3 presents the prevalence ratios for selected risk factors and wheezing illness, asthma, and bronchial asthma in elementary schools. Boys were more likely to have ever wheezed (PR = 1.38, 95%CI 1.11, 1.72). Family history of asthma was strongly associated to ever wheezed (PR = 2.00, 95%CI 1.59, 2.52), wheeze during the previous year (PR = 2.01, 95%CI 1.54, 2.62), a severe attack that required an ER visit (PR = 2.92, 95%CI 2.25, 3.78), asthma diagnosis (PR = 2.33, 95%CI 1.86, 2.92), and bronchial asthma diagnosis (PR = 2.45, 95%CI 1.84, 3.27). The observed associations for family history of asthma and wheezing illness remained statistically significant after multiple comparisons were considered (*p* < 0.002).

Junior-High Schools

A total of 1,334 junior-high school students completed the questionnaire; the participation rate was 78%. Table 2 presents the prevalence estimates; lifetime wheezing was reported by 34% of the children, while only 20% reported they have had an attack during the previous year. Lifetime asthma

TABLE 3.—Selected risk factors with prevalence ratios[†] for respiratory health in elementary school children: Rio Grande and Loíza Municipalities, Puerto Rico (n = 1,467).

	Respiratory symptoms and conditions									
	Ever wheezed		Wheezed previous yr		Attack ER visit		Asthma		Bronchial asthma	
	PR	95%CI	PR	95%CI	PR	95%CI	PR	95%CI	PR	95%CI
Type of school (%)										
Private (13.5)	1.00	—	1.00	—	1.00	—	1.00	—	1.00	—
Public (86.5)	0.81	0.59, 1.09	0.81	0.58, 1.13	1.03	0.74, 1.43	0.92	0.68, 1.24	0.78	0.55, 1.12
Gender										
Female (49.5)	1.00	—	1.00	—	1.00	—	1.00	—	1.00	—
Male (50.4)	1.38	1.11, 1.72**	1.26	0.99, 1.61	1.25	1.00, 1.57	1.23	0.99, 1.52	1.02	0.79, 1.33
Age, yrs										
6 (47.7)	1.00	—	1.00	—	1.00	—	1.00	—	1.00	—
7 (52.3)	0.98	0.79, 1.22	1.03	0.81, 1.31	1.04	0.83, 1.30	1.02	0.82, 1.26	0.93	0.72, 1.21
Family history of asthma (58.3)	2.00	1.59, 2.52***	2.01	1.54, 2.62***	2.92	2.25, 3.78***	2.33	1.86, 2.92***	2.45	1.84, 3.27***
Smoker in household (31.1)	1.06	0.84, 1.34	0.91	0.70, 1.18	1.08	0.84, 1.39	1.26	1.00, 1.58*	1.02	0.77, 1.35

* *p* = 0.05.

** *p* < 0.01.

*** *p* < 0.0001.

[†]Prevalence ratios obtained by simple logistic regression, 95%CI: 95% confidence interval.

TABLE 4.—Selected risk factors with prevalence ratios[†] for respiratory health in junior-high school children: Río Grande and Loíza Municipalities, Puerto Rico ($n = 1,334$).

	Respiratory symptoms and conditions									
	Ever wheezed		Wheezed previous yr		Attack ER visit		Asthma		Bronchial asthma	
	PR	95%CI	PR	95%CI	PR	95%CI	PR	95%CI	PR	95%CI
Type of school (%)										
Private (6.7)	1.00	—	1.00	—	1.00	—	1.00	—	1.00	—
Public (93.3)	0.63	0.41, 0.98*	0.91	0.53, 1.54	2.85	1.03, 7.89**	0.61	0.38, 0.97*	0.59	0.30, 1.15
Gender										
Female (56.0)	1.00	—	1.00	—	1.00	—	1.00	—	1.00	—
Male (44.0)	0.52	0.41, 0.66***	0.42	0.34, 0.62***	0.55	0.38, 0.79**	1.16	0.90, 1.50	1.06	0.71, 1.59
Age, yrs										
13 (51.4)	1.00	—	1.00	—	1.00	—	1.00	—	1.00	—
14 (48.6)	0.93	0.74, 1.18	1.03	0.78, 1.36	0.82	0.58, 1.16	0.82	0.64, 1.06	0.66	0.44, 1.00
Family history of asthma (50.4)	2.01	1.56, 2.57***	2.00	1.47, 2.73***	2.32	1.57, 3.44***	2.72	2.06, 3.60***	2.19	1.42, 3.38***
Smoker in Household (29.9)	0.96	0.75, 1.24	1.13	0.84, 1.52	1.28	0.89, 1.85	1.01	0.76, 1.34	1.14	0.74, 1.77

* $p < 0.05$.** $p < 0.01$.*** $p < 0.0001$.[†]Prevalence ratios obtained by simple logistic regression, 95%CI: 95% confidence interval.

diagnosis was reported by 24%, and 11% reported that they had attacks that required visits to the ER. For those who reported wheezing attacks during the previous year, nearly 30% reported they had more than three attacks during the previous year, 43% reported sleep disturbances by wheezing attacks, in 40% their speech was limited by attacks, 60% had attacks after exercise, and 47% had wheezing apart from colds.

Table 4 presents the prevalence ratios for selected risk factors and wheezing illness in junior-high schools. Children from public schools were less likely to report that they have ever wheezed (PR = 0.63, 95%CI 0.41, 0.98) and less likely to report asthma (PR = 0.61, 95%CI 0.38, 0.97). However, they were more likely to report a severe attack that required a visit to the ER (PR = 2.85, 95%CI 1.03, 7.89). Additionally, boys were less likely to report they had ever wheezed (PR = 0.42, 95%CI 0.34, 0.62), had wheezing attacks during the previous year (PR = 0.62, 95%CI 0.41, 0.94), and were less likely to have ER room visits (PR = 0.55, 95%CI 0.38, 0.79). Family history was strongly associated with ever wheezed (PR = 2.01, 95%CI 1.56, 2.57), visits to the ER (PR = 2.32, 95%CI 1.57, 3.44), wheezing during the previous year (PR = 2.00, 95%CI 1.47, 2.73), asthma diagnosis (PR = 2.72, 95%CI 2.06, 3.60), and bronchial asthma diagnosis (PR = 2.19, 95%CI 1.42, 3.38). The observed association for gender and ever wheezed and for family history and wheezing illness remained significant after multiple comparisons were considered ($p < 0.002$).

DISCUSSION

The main result of this survey is the high prevalence of asthma observed in northern Puerto Rico. Approximately 46% of the 6- to 7-year olds and 24% of the 13- to 14-year olds have been told by a physician that they have asthma. These results support previous reports of high prevalence of asthma among Puerto Rican children (9, 10, 12). Genetics may partially explain these high estimates. Some evidence suggests that certain genetic compositions can predispose subjects to asthma. Colp et al. proposed that variants S and Z of alpha 1-antitrypsin (AAT) affect the inflammatory response in such a

way as to predispose to asthma (16). Their research has shown that these variants are more common in asthmatic children of Puerto Rican descent (16, 17). They also reported that family history of asthma was more common in asthmatic than control subjects, and it was more common for AAT phenotypes either in asthmatics or control subjects (16). Other studies have also shown that genetic variants at the beta₍₂₎-adrenergic receptor (beta₍₂₎AR) may modify asthma severity and albuterol responsiveness among Puerto Rican children (18). Although the studies comparing Puerto Rican children with other ethnic groups have consistently shown higher asthma morbidity among Puerto Ricans (4-8), most of these studies have been conducted outside Puerto Rico. Therefore, the question that remains unanswered is *Why do Puerto Rican children living in the Island present rates that are much higher than the rates observed among Puerto Rican children elsewhere?*

Gene-environment interactions may provide an answer to this question, as they play an important role in the occurrence of asthma; and studies conducted in different locations around the world (different genetic characteristics) have shown a high prevalence of asthma in tropical environments (19-21). It is possible that the unique tropical characteristics of Puerto Rico, combined with the genetic characteristics of the study population, may have both influenced the occurrence of asthma resulting in the observed increased prevalence rate in the present study. Although the current study is limited by lack of data on environmental factors, such as temperature, humidity, and indoor/outdoor allergens, such conditions do not vary greatly across yearly seasons and are expected not to affect the results of the study as they remain uniform all year around. In fact, a recent study that evaluated the risk for asthma attacks and distance to air pollution sources in Puerto Rico found that wind direction, temperature, and humidity did not modify the observed association (22).

Other factors that may also be related to the high prevalence estimates in the Island are practices on asthma diagnosis and participation bias. First, overdiagnosis of asthma may partially explain the high estimates. Researchers in San Juan developed a questionnaire (based on the National Heart,

Lung and Blood Institute guidelines) to evaluate the knowledge of asthma among physicians in the Internal Medicine Residency Program (23). The results showed that 51% of the residents failed to obtain a total score of 70% or higher; the score on asthma diagnosis was less than 70% and did not improve through the year of training. These researchers concluded that there was a need to reinforce the state-of-the-art asthma education for physicians. If there is overdiagnosis of asthma, a cross-sectional prevalence survey (such as the current study) using the question *Have you ever been told by a physician that you have asthma?* will result in a high prevalence estimate.

Furthermore, even if there is no overdiagnosis of asthma, then one might consider the possibility of participation bias in the prevalence surveys. It is possible that parents of children with asthma are more willing to participate or let their children participate in the surveys, as compared to parents of healthy children. This bias leads to asthma prevalence estimates that are artificially increased. Participation bias is possible in the present study; however, to minimize it specific information about asthma was not provided before the parents agreed to participate. Despite this effort, a regression analysis with asthma prevalence rates as the dependent variable and participation rates as the explanatory variable showed that schools with higher participation rates also had higher asthma prevalence rates ($p < 0.05$, data not shown) (13), which suggests that in this study parents of asthmatic children were more likely to participate than parents of healthy children. Nonetheless, the results are supported by estimates reported in previous studies (9, 10, 12).

Another important finding of this study was the fact that family history of asthma was strongly associated with asthma and wheezing illness; previous studies support this finding (24, 25). These observed associations for family history with asthma diagnosis and related symptoms are suggestive of a strong genetic component among Puerto Ricans. If a high proportion of individuals are genetically predisposed to asthma, the unique environmental tropical characteristics of Puerto Rico can have an additive effect resulting in a much higher incidence of asthma. Unfortunately, few studies have been conducted in Puerto Rico to evaluate genetics, sensitivity, and environmental exposures; and they are limited by the fact that they evaluate exposures and sensitivity levels among asthmatics and not the development of the disease (24, 26–28). Nonetheless, they provide valuable data on exposure levels, sensitivity levels, and the effect of exposures among subjects who are already identified as asthmatics.

Another aspect evaluated by this study was asthma severity. These data could be limited by recall bias since some of the severity questions were related to asthma attacks during the previous year. If recall bias is present in this study, one likely scenario is for the participants to not recall correctly the severity of asthma attacks during the previous year. This will actually result in underestimation of the outcomes, which may not be the case in this study as all measurements for severity during the previous year were higher than 25% in both elementary and junior-high school children.

Finally, this study failed to show significant associations between exposure to smoking in the house and respiratory health. This may have been the result of information bias that led to the misclassification of exposure to environmen-

tal tobacco smoke. The indicator for exposure was the self-reported presence of a smoker in the house. Parents of asthmatic children may not feel comfortable to report that there is a smoker in the house, as it may not be well perceived and accepted. Similarly, asthmatic children may respond similarly and not report that there is a smoker in their house. The misclassification of exposed children as non-exposed may have diluted the prevalence ratio towards the null hypothesis. In contrast, reports from the scientific literature have shown that exposure to smoking is a well-known risk factor for asthma exacerbations (29–31).

In conclusion, further research on asthma, its symptoms, and risk factors is needed in Puerto Rico. Asthma is a public health problem in Rio Grande and Loíza, and it might well be in the rest of the Island. There is a need for a comprehensive evaluation of environmental risk factors that can either induce the development of asthma or trigger asthma exacerbations. Special attention should be given to genetics, sensitivity levels, indoor air quality, outdoor pollution and allergens, and gene-environment interactions.

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REFERENCES

1. Weiss KB, Sullivan SD. The health economics of asthma and rhinitis. I. Assessing the economic impact. *J Allergy Clin Immunol* 2001; 107:3–8.
2. Mannino DM, Homa DM, Akinbami LJ, Moorman JE, Gwynn C, Redd SC. Surveillance for asthma—United States, 1980–1999. *MMWR Surveill Summ* 2002; 51:1–13.
3. Health Data for All Ages (HDAA). In: US Department of Health and Human Services (HHS), Centers for Disease Control and Prevention (CDC), National Center for Health Statistics (NCHS); 2005. Health statistics for all ages US population.
4. Carter-Pokras OD, Gergen PJ. Reported asthma among Puerto Rican, Mexican-American, and Cuban children, 1982 through 1984. *Am J Pub Health* 1993; 83:580–582.
5. Crain EF, Weiss KB, Bijur PE, Hersh M, Westbrook L, Stein RE. An estimate of the prevalence of asthma and wheezing among inner-city children. *Pediatrics* 1994; 94:356–362.
6. Beckett WS, Belanger K, Gent JF, Holford TR, Leaderer BP. Asthma among Puerto Rican Hispanics: a multi-ethnic comparison study of risk factors. *Am J Respir Crit Care Med* 1996; 154(4 Pt. 1):894–899.
7. Ledogar RJ, Penchaszadeh A, Garden CC, Iglesias G. Asthma and Latino cultures: different prevalence reported among groups sharing the same environment. *Am J Pub Health* 2000; 90:929–935.
8. Findley S, Lawler K, Bindra M, Maggio L, Penachio MM, Maylahn C. Elevated asthma and indoor environmental exposures among Puerto Rican children of East Harlem. *J Asthma* 2003; 40:557–569.
9. Perez-Perdomo R, Perez-Cardona C, Disdier-Flores O, Cintron Y. Prevalence and correlates of asthma in the Puerto Rican population: Behavioral Risk Factor Surveillance System, 2000. *J Asthma* 2003; 40:465–474.
10. Nazario S, Casal JR, Torres-Palacios A, Rodriguez W, Delamater AM, Applegate EB, et al. Parent-reported asthma in Puerto Rican children. *Pediatr Pulmonol* 2004; 37:453–460.

11. Mayol PM, Rodriguez Santana JR, Sinfuentes JE, Mirabal M, Beltran N. Profile of pediatric admissions with diagnosis of asthma at the San Pablo Hospital. *Bol Asoc Med P R* 1991; 83:426–429.
12. Montealegre F, Bayona M, Chardon D, Trevino F. Age, gender, and seasonal patterns of asthma in emergency departments of southern Puerto Rico. *P R Health Sci J* 2002; 21:207–212.
13. Orengo JC, Loyo-Berríos NI, Serrano RA, Mercado HE, Maisonet M, White M. Prevalence of Respiratory and Allergic Problems Among School-Aged Children in the Cataño Air Basin: Final Report: Environmental Health Secretariat, Puerto Rico Department of Health; Center for Disease Control; Agency for Toxic Substances and Disease Registry; 1996 April.
14. Cataño Workshop Final Report: The Cataño Air Basin Asthma Prevalence Study, 1996. San Juan: Environmental Health Secretariat, Puerto Rico Department of Health, PR Governor's Office, US Environmental Protection Agency; 1997 February.
15. Asher MI, Weiland SK. The International Study of Asthma and Allergies in Childhood (ISAAC). ISAAC Steering Committee. *Clin Exp Allergy* 1998; 28 (suppl. 5):52–66; discussion 90–91.
16. Colp C, Pappas J, Moran D, Lieberman J. Variants of alpha 1-antitrypsin in Puerto Rican children with asthma. *Chest* 1993; 103:812–815.
17. Colp C, Talavera W, Goldman D, Green J, Multz A, Lieberman J. Profile of bronchospastic disease in Puerto Rican patients in New York City. A possible relationship to alpha 1-antitrypsin variants. *Arch Intern Med* 1990; 150:2349–2354.
18. Choudhry S, Ung N, Avila PC, Ziv E, Nazario S, Casal J, et al. Pharmacogenetic differences in response to albuterol between Puerto Ricans and Mexicans with asthma. *Am J Respir Crit Care Med* 2005; 171:563–570.
19. Dawson AP. Asthma in the Australian Indigenous population: a review of the evidence. *Rural Remote Health* 2004; 4:238.
20. Soto-Quiros ME, Soto-Martinez M, Hanson LA. Epidemiological studies of the very high prevalence of asthma and related symptoms among school children in Costa Rica from 1989 to 1998. *Pediatr Allergy Immunol* 2002; 13:342–349.
21. Carey MJ, Cordon I. Asthma and climatic conditions: experience from Bermuda, an isolated island community. *Br Med J (Clin Res Ed)* 1986; 293(6551):843–844.
22. Loyo-Berríos N. Outdoor Air Pollution and Asthma Attacks in Cataño Puerto Rico: 1997 to 2001. Baltimore: Johns Hopkins University, Bloomberg School of Public Health; 2004.
23. Alicea E, Casal J, Nazario S, Rodriguez W. Asthma knowledge among internal medicine residents. *P R Health Sci J* 1999; 18:19–21.
24. Montealegre F, Chardon D, Tarrats H. Environmental factors precipitating bronchial asthma exacerbations in southern Puerto Rico: a pilot study. *J Asthma* 1993; 30:219–227.
25. Garcia-Marcos L, Castro-Rodriguez JA, Suarez-Varela MM, Garrido JB, Hernandez GG, Gimeno AM, et al. A different pattern of risk factors for atopic and non-atopic wheezing in 9–12-year-old children. *Pediatr Allergy Immunol* 2005; 16:471–477.
26. Montealegre F, Fernandez B, Delgado A, Fernandez L, Roman A, Chardon D, et al. Exposure levels of asthmatic children to allergens, endotoxins, and serine proteases in a tropical environment. *J Asthma* 2004; 41:485–496.
27. Montealegre F, Meyer B, Chardon D, Vargas W, Zavala D, Hart B, et al. Comparative prevalence of sensitization to common animal, plant and mould allergens in subjects with asthma, or atopic dermatitis and/or allergic rhinitis living in a tropical environment. *Clin Exp Allergy* 2004; 34:51–58.
28. Montealegre F, Quinones C, Michelen V, Bayona M, Fernandez-Caldas E, Vazques O, et al. Prevalence of skin reactions to aeroallergens in asthmatics of Puerto Rico. *P R Health Sci J* 1997; 16:359–367.
29. Feleszko W, Zawadzka-Krajewska A, Matysiak K, Lewandowska D, Peradzynska J, Dinh QT, et al. Parental tobacco smoking is associated with augmented IL-13 secretion in children with allergic asthma. *J Allergy Clin Immunol* 2006; 117:97–102.
30. Lannero E, Pershagen G, Wickman M, Nordvall L. Maternal smoking during pregnancy increases the risk of recurrent wheezing during the first years of life (BAMSE). *Respir Res* 2006; 7:3.
31. Magnusson LL, Olesen AB, Wennborg H, Olsen J. Wheezing, asthma, hayfever, and atopic eczema in childhood following exposure to tobacco smoke in fetal life. *Clin Exp Allergy* 2005; 35:1550–1556.