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ORIGINAL ARTICLE

The New York City Puerto Rican Asthma Project: Study Design, Methods, and Baseline Results

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Objective. We examined asthma risk factors among 274 Puerto Rican children born in New York to atopic mothers. *Methods*. We prospectively followed the cohort to measure aeroallergens in their homes and assess allergic sensitization. Baseline data are presented. *Results*. Maternal smoking was significantly higher among women born on the continental United States (25%) vs. those born elsewhere (11%). Cat ownership was more frequent among mainland-born women (15%) compared with those born in Puerto Rico (4%). While some aeroallergens were prevalent, few dust samples contained detectable dust mite allergens. *Conclusions*. By following this cohort, we hope to identify the roles that socio-cultural factors play in the process of allergic sensitization.

Keywords Birth cohort, asthma, allergy, dust mite, Puerto Rican

INTRODUCTION

The prevalence of asthma among Puerto Rican children in the United States has often been reported as being higher (18–35%) than that of children of other Hispanic subgroups and ethnicities (African-American, Mexican, Dominican, Cuban, non-Hispanic white) (1–6) but little research has been conducted within the Puerto Rican community to explain this disparity (7). Of the 5 boroughs of New York City (NYC), the Bronx has a high proportion of total persons below the poverty level (30.7%), a high percentage of Puerto Ricans (24.2%) (1), and had the highest number of asthma hospitalizations for children under age 15 (9.16 per 1,000 children) (2).

Because allergy is often strongly associated with childhood asthma (3, 4) we sought to study risk factors for allergic sensitization, which could possibly contribute to this disparity. We focused on early life exposure to indoor allergens, particularly dust mite allergens. Since children from Puerto Rican families with strong ties to the island are likely to travel to Puerto Rico (5), we hypothesized that during these trips, they would be exposed to higher levels of mite allergens than those found in houses and apartments in the northeastern United States (6).

We identified a birth cohort of Puerto Rican newborns born in NYC that had a maternal history of asthma and/or inhalant allergy. We assessed travel between NYC and Puerto Rico and the indoor allergen levels in their home environment in NYC and in the homes in Puerto Rico that they visited during the first 4 years of life. The overall goal was to identify the critical period, levels and duration of exposure required for sensitizing atopically predisposed children to dust mite allergens, and how acculturation and social ties to Puerto Rico influence their exposure to dust mite and other allergens and in turn the development of persistent wheeze/asthma. This manuscript describes the methodology of the longitudinal study, as well as the cohort's baseline data (e.g., demographics, mother's history of allergy and asthma, home, building, and immediate neighborhood characteristics, and baseline indoor allergen levels).

METHODS

Study Population

In 2002, 27% of the 8 million NYC residents identified themselves as Hispanic (7). In addition, 10,678 live births in NYC were recorded for women of Puerto Rican ancestry, and 4,777 of those occurred in the Bronx borough of NYC (7). Between November 2002 and December 2004, 555

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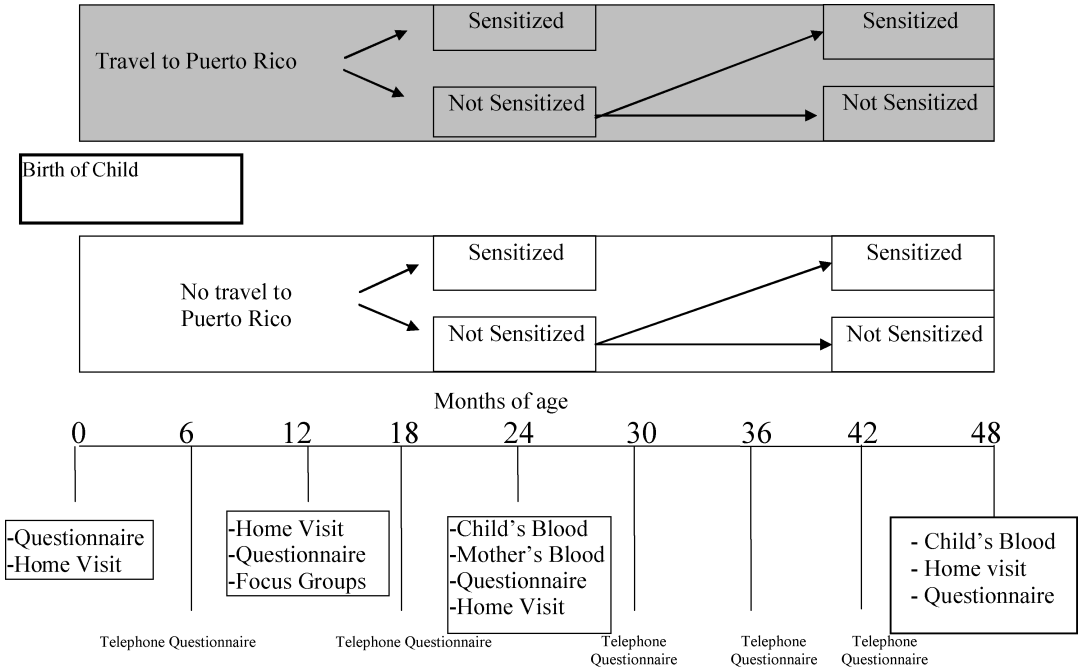

FIGURE 1.—Schematic of study design. Travel is shaded to indicate that time and duration of travel to Puerto Rico will be different for each child. We call by telephone every 3 months to confirm address and maintain contact.

eligible women were screened after they gave birth in three hospitals in the Bronx. The overall study design is shown in Figure 1. Participants met the following inclusion criteria: (1) newborn of Puerto Rican ethnicity (although the mother was not required to be Puerto Rican she must have identified her child as being of Puerto Rican ethnicity); (2) mother of infant had asthma and/or inhalant allergy; (3) maternal age $\geq$16 yr; and (4) residence within NYC area and planned to remain in the NYC area for 4 years. Children with major congenital health problems, pre-term birth ($<$ 36 wk), or intubation and mechanical ventilation were excluded.

Of the eligible women screened, 316 consented to be visited in their homes for a baseline interview and sample collection, and 274 pairs of mothers and their newborns completed the baseline home visit. Informed written consent was obtained from the women in accordance with the institutional review boards of Lincoln Hospital, Albert Einstein Medical Center, and Columbia and Harvard Universities.

Baseline Visit

Home visits to 274 homes were conducted shortly after birth (mean and std. dev $= 45 \pm 39$ days). A team of two technicians, one of whom was bilingual (Spanish/English), collected environmental samples and administered a questionnaire to the mother.

Questionnaire. The baseline questionnaire assessed parental asthma and allergies, past travel to Puerto Rico, home characteristics, a 4-month recall of the indoor environment (e.g., furnishings, cleaning regimens, the presence of pets and pests, and reports of dampness), socioeconomic status (household income, mother's education, and father's education) as well as other sociodemographic characteristics of the mother/guardian, and level of acculturation for the mothers/guardians assessed by generational status: first generation (island-born), second generation (mainland-born of island-born parents), and $\geq$ third generation (i.e., mainland-born of mainland-born parents); number of years in the United States for those who were island-born; language preference, and a biculturality scale (8).

Environmental Sampling. Dust samples from the mother's bed, bedroom floor, and kitchen floor were vacuumed with a Eureka Mighty Mite canister vacuum (The Eureka Co., Bloomington, IL), an ALK dust collection nozzle attachment (ALK, Hørsholm, Denmark), and a pre-weighed Whatman 70 mm cellulose filter (Whatman International, Ltd., England). All surfaces that could contact the filter, possibly causing cross-sample contamination, were cleaned with isopropanol between each sample collection. Separate dust samples were collected from the mother's bed, bedroom floor, and kitchen floor according to the following standardized protocols. The upper half of the mother's bed, including mattress and pillows, were vacuumed for 3 minutes. A separate filter of dust was collected from the bedroom floor by vacuuming 2 square meters of the floor adjacent to the bed for 3 minutes. In kitchens, the floor was vacuumed for 3 minutes, concentrating on edges by cabinets, and around the refrigerator. If a rug was present in the bedroom or kitchen, at least 1 minute was devoted to sampling the rug. After sampling, each filter was sealed in a plastic bag and returned to the laboratory the same day for post-weighing. Bedroom and kitchen dust samples were stored at -20°C until analysis for indoor allergens by immunoassay.

Follow-up visits

Follow-up Questionnaires. Follow-up telephone contacts every 3 months were used for collecting information on

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traveling to Puerto Rico and other areas out of NYC as well as to index child's occurrence of respiratory symptoms. Every six months a more extensive questionnaire was administered over the telephone to determine respiratory illnesses, the use and type of medication for wheeze/asthma, and changes in environmental and host factors. When the child reached age six months, we administered an additional set of questions to the mother regarding perceived stress (9).

Follow-up Environmental Sampling. Follow-up home visits were conducted when the child turned 1, 2, and 4 years to collect dust samples from the child's bed in addition to the same locations sampled during the baseline visits. If a child moved within the tri-state area (New York, New Jersey, Connecticut), the new homes were sampled at the scheduled timepoint. Locations in Puerto Rico that were visited by the children within the first four years of life were also sampled for dust. During our 3-month brief phone contacts with the primary caregiver, we ascertained if the child had visited Puerto Rico in the past 3 months or intended to visit Puerto Rico in the next 3 months. If the child had visited Puerto Rico, then we asked for relevant contact information, and obtained permission from the host(ess) to collect a dust sample from the beds where the child and mother slept, bedroom floor, and kitchen. Visits to Puerto Rico were scheduled every 4 months (approximately once in November, February, and June) to conduct sampling. During each 1-week visit, an environmental technician traveled throughout the island (the distance from San Juan on the northeast coast to Mayagüez on the west coast is 94 miles) to sample the locations where the child slept.

Blood Collection. When the child turned 2 and 4 years, we collected blood samples from the index child to measure serum total and antigen-specific IgE (including anti-*Dermatophagoides pteronyssinus*, *D. farinae*, *Blomia tropicalis*, *Blatella germanica*, *Felis domesticus*, and *Mus musculus*). Blood samples were collected in the home or in the pediatric blood drawing unit of Columbia University Medical Center according to the preference of the participant. Maternal blood was also collected when the child turned age 2.

Focus Groups and In-depth Interviews

We conducted 4 focus groups (6–8 of our participating mothers per group for a total of 32 participants) and 25 in-depth individual interviews to assess migratory motivation, Puerto Rican identity in the United States, perceived discrimination, travel and other ties to Puerto Rico, language use, and return migration. Our objective was to improve our understanding of the types and intensity of social ties to Puerto Rico among this population, and the participants' knowledge of allergy/asthma etiology and management. Both focus groups and interviews were conducted in either English or Spanish depending on the language preference expressed by the respondent(s). Detailed description of the assessment and results from the qualitative data will be presented in a separate publication.

Geographic Information

Using geocoded addresses from the participants at different points in time, 2000 U.S. Census data, and data from OASIS-NYC (Open Accessible Space Information System-New York City) (10), we are developing a picture of the buildings, neighborhoods (i.e., census tracts) and community districts in which participants live. This information will include building characterization, such as building age, mixed residential/commercial, and building violations; neighborhood characteristics such as poverty rate, density, and proportion Puerto Rican/Hispanic; and community district characterization, such as percentage of open space, tree canopy, and proximity to parks.

Allergen Analyses

Dust from the bed samples were extracted in phosphate-buffered saline (PBS) pH 7.4 for 1 hour at room temperature (11). Dust extracts were serially diluted in phosphate-buffered saline with 1% bovine serum albumin and 0.05% Tween 20 (BSA-PBS-T) at pH 7.4. Two-site monoclonal antibody (MAB) sandwich ELISA's for dust mite (Der p 1, Der f 1), and cat (Fel d 1) allergens, and a MAB/polyclonal immunoassay for German cockroach allergen (Bla g 2) were used (Indoor Biotechnologies, Charlottesville, VA) (11–13). Mouse urinary protein (MUP) was assayed by an inhibition ELISA using polyclonal antibodies (Greer Labs, Inc.) as previously described (14). The lower limits of detection (LOD) were as follows: Der f 1 and Der p 1 = 0.25 μg/g; Fel d 1 = 0.2 μg/g; Bla g 2 = 0.04 μg/g (1 Unit = 40 ng) and MUP = 0.75 μg/g. Measurements that were below the limit of detection (LOD) were assigned half of the LOD.

RESULTS

Compared to the 281 women who were eligible but did not consent to a home visit, those who were enrolled ($n = 274$ with a baseline home visit) were more likely to have a self-report of asthma (63% vs. 34%, OR = 3.3, 95% CI (2.3–4.8)). Most of the enrolled women identified as Latina (Puerto Rican = 92%, Dominican = 5%, Mexican = 1%, Other = 2%); only one woman from Guyana did not identify as Latina. For a third of the women, this infant was their only child. Another third reported two children and the rest of the women had 3–9 biological children.Detailed demographic data is shown in Table 1. Briefly, almost 70% of the women reported receiving some kind of public assistance (e.g., housing, food stamps, healthcare). Also, 70% of the women were not married; however, this did not mean that they were alone in taking care of their newborn infant. Seventy-four percent (203/274) reported a live-in partner, and 51% indicated that an adult other than the biological father helped with the care of the child. Overall, we had a range of educational level attained by the women in our study, 35% had not completed high school, but 22% had graduated from college.

Because report of allergy or asthma was one of the inclusion criteria, a high percentage of our women reported allergy (78%) or asthma (64%) whether it was ever diagnosed by a physician or not (Table 2). The percentage of self-reported asthma and doctor-diagnosed asthma was not very different (64% vs. 63%); however, more women reported ever having inhalant allergy vs. doctor-diagnosed inhalant allergy (78% vs. 68%). When stratified by ethnicity, this difference was significant among non-Puerto Ricans (Fisher's exact Chi square $p < 0.03$).

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TABLE 1.—Demographics.

Characteristic	*n*	%
Gender of the child		
Male	139	51
Female	135	49
Mother's age		
<20	15	5.5
20–24	96	35
25–29	67	24
30–34	64	23
35–39	25	9
40+	7	2.5
Marital status		
Married	81	30
Not married	193	70
Mother's place of birth		
Mainland USA	203	74
Puerto Rico	55	20
Other country	16	6
Mother's education		
Not completed high school	95	35
Completed high school	58	21
Some college not degree	60	22
College degree or higher	61	22
Health coverage		
Mother is covered	263	96
Child is covered	259	95
Household receives public assistance	190	69
Household total annual income (in previous year)		
Less than $ 5,000	44	16
$ 5,000–9,999	48	18
$ 10,000–19,999	61	22
$ 20,000–29,999	40	15
$ 30,000–39,999	26	9
$ 40,000–49,999	25	9
$ 50,000–more	30	11
Number of people currently living in residence		
2–3	54	19.5
4–5	150	54.5
6–7	51	19
8+	19	7
Other adult caretaker of child*		
Yes	133	49
No	141	51

*Other than the biological father of the child.

TABLE 2.—Maternal background of asthma and allergy.

		Birthplace		
	Total (%) ($n = 274$)	Mainland (%) ($n = 203$)	Puerto Rico (%) ($n = 55$)	Other country (%) ($n = 16$)
Self-report asthma				
Yes	63.5	66.5	58	44
No	36	33.5	42	50
DK	0.5	0	0	6
Asthma diagnosed				
Yes	63	66	58	44
No	36.5	34	42	50
DK	0.5	0	0	6
Self-report respiratory allergy				
Yes	78	77	75	100
No	22	23	25	0
DK	0	0	0	0
Respiratory allergy diagnosed				
Yes	68	69	67	62.5
No	31.5	30.5	34	37.5
DK	0.5	0.5	0	0
Self-report hay fever				
Yes	35	37	31	19
No	61	59	65	75
DK	4	4	4	6
Hay fever diagnosed				
Yes	32	34	29	13
No	64	62	67	81
DK	4	4	4	6

TABLE 3.—Home characteristics.

		Birthplace		
	Total (%) ($n = 274$)	Mainland (%) ($n = 203$)	Puerto Rico (%) ($n = 55$)	Other country (%) ($n = 16$)
Type of housing*				
Apartment building ≥8 floors	18	19	19	8
Apartment building <8 floors	59	57	65	54
House/duplex	23	24	16	38
Presence of pets in household				
Yes	43	44	38	37.5
No	57	56	62	62.5
Cat	12	15	4	6
Dog	16	17	14	19
Bird	9	7	17	13
Fish	12	12	11	13
Other	8	8	9	6
Self-reported presence of roaches				
None	27	30	13	37.5
Monthly	17.5	16	24	12.5
Weekly	14.5	12	25	6
Daily	41	42	38	44
Self-reported presence of mice				
None	59	60	60	43.5
Monthly	15	16	14.5	13
Weekly	11	10	11	25
Daily	15	14	14.5	18.5
Self-reported presence of rats				
None	98	98.5	96	100
Monthly	1	1	2	0
Weekly	0	0	0	0
Daily	1	0.5	2	0
Maternal smoking				
Yes	22	25	13	6
No	78	75	87	94
Any environmental tobacco smoke in home				
Yes	38	49.5	36	20
No	62	50.5	64	80

*The samples size for this question does not equal 274 because this question was added after the first 50 participants were enrolled.

For several home characteristics, we stratified by place of birth (i.e., Mainland, Puerto Rico, Other) rather than ethnicity (Table 3). For example, we found that maternal smoking was significantly higher ($p = 0.015$) among those born on the mainland (25%) compared with those born elsewhere (11%). A similar result was observed between mainland and Puerto Rican birthplace (13%), although less significant ($p = 0.051$). Cat ownership was significantly more frequent among mainland-born women compared with those born elsewhere ($p = 0.015$) and still significant when compared with only women born in Puerto Rico ($p = 0.022$). Conversely, bird ownership was more common among Puerto Rican-born women ($p = 0.042$) compared with that among mainland-born women. We did not detect a significant difference in self-reported roach or rodent infestation when stratified by place of birth.

In Figure 2, allergen concentrations in the bed dust collected at baseline are displayed as geometric means (GM) and standard deviations (GSD). Very few samples had Der p 1, so dust mite allergen was presented as Der f 1 or Der p 1. The median concentrations for dust mite, cockroach, cat, and mouse allergens were 0.13 μg/g, 0.02 μg/g, 0.49 μg/g, and 0.38 μg/g, respectively. While the cockroach, cat, and

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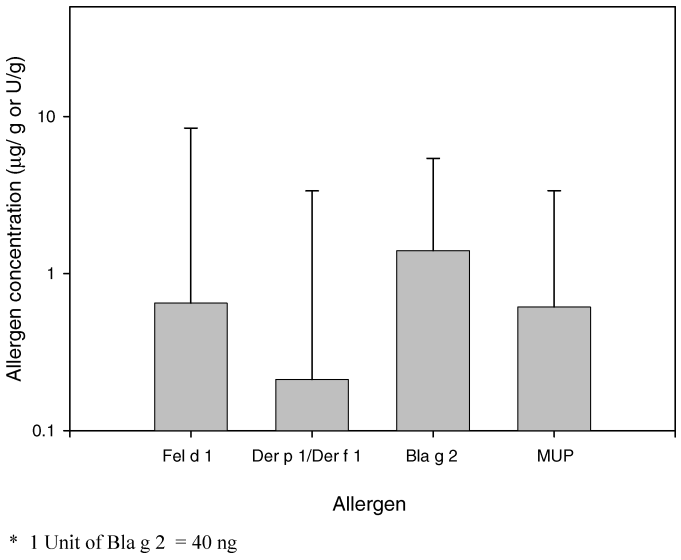

FIGURE 2.—Allergen levels in bed dust samples ($n = 267$). Bars indicate geometric means and standard deviations.

mouse allergen concentrations showed wide variability, the measurements of dust mite allergen exhibited less variability.

DISCUSSION

Our recruitment strategy resulted in a group of participants with varied levels of acculturation. While all of the children were born in New York, 74% of the mothers were born in the mainland United States, 20% were born in Puerto Rico, and 6% were born in another country (mainly The Dominican Republic). This range of ties to Puerto Rico may result in different travel patterns, thus enabling evaluation of exposure (period of time exposed, and concentration of dust mite allergen) in more of a continuous manner, rather than only dichotomously.

Our recruitment also resulted in a cohort of primarily low-income participants, reflecting the socioeconomic profile of the Puerto Rican population in the Bronx. The average proportion of total persons below the poverty level in the New York City Primary Metropolitan Statistical Area (PMSA) was 19.5%, whereas in the Bronx it was 30.7% (1). Yet within the census tracts in which this study population lives, the average proportion of total persons below the poverty level was 33.2%. Two large inner-city asthma studies also had sites in New York (15, 16). Neither of these studies provided the percentage of participants living below the poverty level; however, they provided the percentage with a household income $<$ \$ 15,000. Then, 60% of the Inner-City Asthma Study (ICAS), 61% of the National Cooperative Inner-City Asthma Study (NCICAS) and 45% of our participants fell below this income level. One caveat for this comparison with the inner-city asthma studies is that poverty is a complex formula that should also take into account the number of people (adults and children) supported by that income.

By design, all of the participating mothers had inhalant allergy and/or asthma. We found that their report of asthma made them more likely to participate in this area of research; this might also be true for studies not purposefully selected on asthma. Nonetheless, self-report can be somewhat subjective. The prevalence of self-report of asthma was not significantly different from their report of doctor-diagnosed asthma, but we did observe a difference in self-report and doctor-diagnosed respiratory allergy. This difference was mainly driven by the group of women born in a country other than the United States or Puerto Rico; all of whom reported having respiratory allergy, but only 63% had a doctor's diagnosis. This study was not designed to determine the reason for this difference (e.g., access to allergy testing, perception of causes of inhalant allergy). However, this discrepancy calls our attention to the importance of using more objective measurements of allergic sensitization such as serum IgE.

A main focus of this study was the assessment of indoor allergen exposure from the birth of the child through age 4 years. Using the mother's bed dust sample as a proxy for early-life exposure, we found that only 5% of the homes had levels of the major dust mite allergens, Der f 1 or Der p 1, ≥ 2 μg/g and only 1.5% were ≥ 10 μg/g. This confirmed our hypothesis that dust mite allergen levels tend to be low in NYC and corroborated results from other studies in the northeastern United States (6, 17). According to Sporik et al. (1990) dust mite allergen above 2 μg/g was associated with development of allergic sensitization and above 10 μg/g was associated with asthma symptoms (4).

High levels of cockroach allergen were common in the bed dust samples collected in New York; 30% of samples had Bla g 2$\geq$2 U/g (i.e., 0.08 μg/g). This percentage was much higher than that observed in the National Survey of Lead and Allergens in Housing (NSLAH) in the United States (1.3% of the 767 beds had Bla g 1$\geq$2 U/g (18). Although the allergens were different (Bla g 2 vs. Bla g 1), previous research has shown a high level of correlation between the two ($r = 0.92$, $p < 0.01$) and an almost one-to-one relationship (19). We suspect that once the kitchen samples are analyzed, they will reveal even higher levels of cockroach allergen as has been shown in one of our previous studies in NYC (20).

Mouse and cat allergens were more common in the home; 71% and 51% had detectable levels of MUP and Fel d 1, respectively. Compared with the NSLAH, the median MUP concentration in our study was slightly higher (0.25 vs. 0.38 μg/g) (21), but the median Fel d 1 was lower (1.50 vs. 0.49 μg/g) (22). We have previously found an inverse relationship between these two allergens in inner-city homes (14). Also, cat ownership was much lower in our study (12%) than in others (22% in Detroit, 23% in New Zealand) where a pet protective effect on allergy and/or asthma has been observed (23, 24).

Discriminating by place of birth enables examination of important differences that could be related to allergy/asthma. For example, our findings on maternal smoking are consistent with reports that show mainland Puerto Ricans have smoking rates two-fold higher (27% vs. 14%) than those of island-born Puerto Ricans (25). Other studies suggest that this difference may be attributed to factors related to acculturation (26–28). Based upon a large meta-analysis, parental smoking has been associated with an increased incidence of wheezing in early life (infancy through age 6) as well as positively associated with the severity of the symptoms (29). In addition, a German study found that among children with parental history of atopy, ETS exposure was associated with dust mite

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sensitization (OR 3.10, 95% CI 1.63–5.90) (30). Hence this difference between mainland- and island-born Puerto Ricans should be considered when assessing children's respiratory outcomes.

Another major difference in place of birth was the presence of cats and birds in the home. Previous literature has shown that cat exposure in early life might protect against development of cat allergy (24, 31–33). While the prevalence of cat or dog ownership in the child's infancy was lower among our study participants (29%) than in the Detroit childhood asthma study (53%) (32), this could still make the association between allergen exposure and allergic sensitization harder to detect. Bird feathers are another source of allergen exposure that has not been well-studied in relation to inner-city asthma. In addition to their feathers, bird excrement also contains fungal spores that could affect the development of sensitization (e.g., fungal allergens and (1→3)-β-D-glucans) (34).

Conclusion

As noted earlier, Puerto Rican adults and children have a higher risk of asthma compared with other ethnicities including African American and other Latino subgroups (35–40). By design, we avoided having to adjust for other ethnicities that could have different environmental and nutritional factors related to the development of allergy and asthma. For example, our main study hypothesis was that travel to Puerto Rico represented additional exposure to allergens from dust mites (which do not thrive in New York) that would increase risk for allergic sensitization. If we had expanded inclusion criteria to enroll other ethnicities, our ability to measure exposures elsewhere (e.g., Mexico and the Dominican Republic) would have required greater financial resources and extensive travel time. By focusing on one ethnicity, we have also addressed concerns voiced by other researchers that acculturation levels within an ethnic group are important determinants of asthma (41).

Also, we studied a population known for their high asthma risk, namely those who have a maternal history of allergy or asthma and those who are of Puerto Rican ethnicity. The increased risk of asthma due to maternal allergy and asthma has been well-established in the literature (42–45). We focused on this population because our main goal was not finding new factors related to increased prevalence of asthma. Rather, we wanted to examine the biologically relevant timing of environmental exposures in early life and how it relates to increased sensitization, given a hereditary predisposition toward developing allergic asthma. This, in effect, increased the epidemiologic efficiency (i.e., enhanced the sample size of those developing allergic asthma early in life). With our prospective birth cohort, we will have a unique opportunity to examine how differences in acculturation can influence allergic sensitization in this high risk inner-city population.

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