

Acculturation is associated with asthma burden and pulmonary function in Latino youth: The GALA II study

Neeta Thakur, MD, MPH,^a Luisa N. Borrell, DDS, PhD,^b Morgan Ye, MPH,^a Sam S. Oh, PhD, MPH,^a Celeste Eng, BS,^a Kelley Meade, MD,^c Pedro C. Avila, MD,^d Harold J. Farber, MD, MSPH,^e Denise Serebrisky, MD,^f Emerita Brigino-Buenaventura, MD,^g William Rodriguez-Cintrón, MD,^h Rajesh Kumar, MD, MSPH,ⁱ Kirsten Bibbins-Domingo, PhD, MD,^a Shannon Thyne, MD,^j Saunak Sen, PhD,^k Jose R. Rodriguez-Santana, MD,^l and Esteban G. Burchard, MD, MPH^{a,m}
San Francisco, Oakland, Vallejo, and Los Angeles, Calif; New York and Bronx, NY; Woodlands and Houston, Tex; San Juan, Puerto Rico; Chicago, Ill; and Memphis, Tenn

Background: Acculturation is an important predictor of asthma in Latino youth, specifically Mexican Americans. Less is known about acculturation and pulmonary function measures.

Objective: We sought to estimate the association of acculturation measures with asthma and pulmonary function in Latino youth and determine whether this association varies across Latino subgroups.

Methods: We included 1849 Latinos (302 Caribbean Spanish, 193 Central or South Americans, 1136 Mexican Americans, and 218 other Latino children) aged 8 to 21 years from 4 urban regions in the United States. Acculturation measures include nativity status, age of immigration, language of preference, and generation in the United States. We used multivariable logistic

and linear regression models to quantify the association of acculturation factors with the presence of asthma (case-control study) and pulmonary function (case-only study), adjusting for demographic, socioenvironmental, and clinical variables.

Results: For all acculturation measures (nativity status, age of immigration, language of preference, and generation in the United States), greater levels of acculturation were associated with greater odds of asthma. Among cases, high (English preference) and medium (equal preference for Spanish and English) levels of language acculturation were associated with decreased bronchodilator response compared with low (Spanish preference) levels ($P = .009$ and $.02$, respectively). Similarly, high language acculturation was associated with increased FEV₁ compared with low language acculturation ($P = .02$). There was insufficient evidence of heterogeneity for associations across Latino subgroups.

Conclusions: Acculturation was associated with diagnosed asthma and pulmonary function in Latino children and is an important factor to consider in the management of Latino youth with asthma. (J Allergy Clin Immunol 2019;■■■:■■■-■■■.)

Key words: Latino, asthma, acculturation, pediatric, health disparities, social determinants of health

From ^athe Department of Medicine and ^mthe Department of Bioengineering & Therapeutic Sciences, University of California, San Francisco; ^bthe Department of Epidemiology and Biostatistics, Graduate School of Public Health and Health Policy, City University of New York, New York; ^cChildren's Hospital and Research Center Oakland; ^dAllergy ENT & Associates, Woodlands; ^ethe Department of Pediatrics, Section of Pulmonology, Baylor College of Medicine and Texas Children's Hospital, Houston; ^fthe Pediatric Pulmonary Division, Jacobi Medical Center, Bronx; ^gthe Department of Allergy and Immunology, Kaiser Permanente-Vallejo Medical Center, Vallejo; ^hVeterans Caribbean Health Care System, San Juan; ⁱthe Ann and Robert H. Lurie Children's Hospital of Chicago; ^jthe Department of Pediatrics, University of California, Los Angeles; ^kthe Department of Preventive Medicine, University of Tennessee Health Science Center, Memphis; and ^lCentro de Neumología Pediátrica, San Juan.

Supported in part by the Sandler Family Foundation, the American Asthma Foundation, the RWJF Amos Medical Faculty Development Program, the Harry Wm. and Diana V. Hind Distinguished Professorship in Pharmaceutical Sciences II, the National Heart, Lung, and Blood Institute (1R01HL117004, 1R01HL128439, 1R01HL135156, and 1X01HL134589), the National Institute of Health and Environmental Health Sciences (R01ES015794 and R21ES24844), the National Institute on Minority Health and Health Disparities (1P60MD006902, U54MD009523, and 1R01MD010443), and the Tobacco-Related Disease Research Program (award no. 24RT-0025). Grant M01-RR00188 went to H.J.F., and N.T. was supported by an institutional training grant from the National Institute of General Medical Sciences (T32-GM007546) and career development awards from the National Heart, Lung, and Blood Institute (K12-HL119997 and K23-HL125551-01A1), the Parker B. Francis Fellowship Program, and the American Thoracic Society. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Disclosure of potential conflict of interest: The authors declare that they have no relevant conflicts of interests.

Received for publication April 30, 2018; revised November 12, 2018; accepted for publication December 24, 2018.

Corresponding author: Neeta Thakur, MD, MPH, Department of Medicine, University of California, San Francisco, 550 16th St, 2nd Floor, San Francisco, CA 94143-0560.

E-mail: Neeta.Thakur@ucsf.edu.

0091-6749/\$36.00

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<https://doi.org/10.1016/j.jaci.2018.12.1015>

In the United States Latinos often have better health outcomes than other minority groups of similar low socioeconomic status¹; this difference is referred to as the Hispanic paradox. Despite living in areas with high exposure to indoor and outdoor pollution^{2,3} and having limited access to regular health care,^{4,5} childhood asthma prevalence is significantly lower among Latinos when compared with African Americans (6.7% vs 15.7%) and lower than in non-Hispanic whites (7.1%).⁶ To explain this paradox, the healthy migrant effect,^{7,8} cultural characteristics,⁹ and acculturation^{10,11} have been proposed.

Despite this paradox, there is high variability in asthma prevalence between Latino subgroups: Puerto Ricans have one of the highest lifetime prevalences of asthma (36.5%) in the United States, followed by Cubans (21.8%) and Dominican Americans (15.4%), whereas Mexican Americans have the lowest (7.5%).¹²⁻¹⁴ Although Latino populations are aggregated into a single ethnic group in the United States and are bound by the Spanish language, there is considerable heterogeneity in their genetic makeup, cultural upbringing, and environmental exposures.^{12,14} Each Latino subgroup has a unique relationship with the United States that not only differs in the types of

Abbreviation used

GALA II: Genes-Environment & Admixture in Latino Americans

environmental exposures but also in the process of immigration to the United States.¹ These differences might translate to varying risks for asthma and related outcomes across Latino subgroups.^{15,16} Several studies have demonstrated that low acculturation is associated with lower odds of asthma in Mexican Americans.¹⁷⁻¹⁹ However, the role of acculturation in asthmatic patients might not only differ by Latino subgroup²⁰ but also by how acculturation is defined. Thus acculturation can play a role in explaining the wide variability in asthma prevalence observed across Latino subgroups in the United States²⁰ and might partially explain the recent trend of increasing asthma prevalence in Mexican Americans.⁶

Although acculturation reflects the adoption of cultures of the dominant society, it also captures the duration of time spent in the host country and thus the changes in early-life exposures to known asthma risk factors.²¹ Therefore studies have argued that the change in socioenvironmental exposures and adaption of the dominant culture's behavioral attributes might explain the observed association between acculturation and asthma and, more recently, lung function.^{19,22,23} Early-life exposures to environmental toxins, including air pollution, are important factors in determining impaired lung function and asthma risk²⁴; thus the country of birth and/or the age at which one immigrates to the United States might be important factors in defining risk. In addition, behaviors associated with acculturation (eg, increased tobacco use and decreased breast-feeding) might increase the risk for asthma and impaired lung function.^{25,26} Therefore including attributes of acculturation that affect changes in behaviors,²¹ such as language preference, would allow for deeper exploration of acculturation.

A systematic review summarizing the association between immigration status with asthma and allergic disease in diverse populations found that in general asthma prevalence was lower in immigrants compared with the host population and, among immigrants, lower in first-generation compared with second-generation immigrants.²⁷ However, of the 54 articles included in this review, only 7 focused on acculturation and Latinos, of which 2 were focused on Mexican American populations,^{17,28} 2 on Puerto Rican and Dominican populations,^{16,29} and 3 on Latinos in aggregate³⁰⁻³²; of these, only 1 assessed pulmonary function.³²

Since the publication of this review, additional studies have examined the relationship between acculturation and asthma in the Mexican American population and found conflicting results. We previously demonstrated that acculturation (defined as generation in the United States) partially explains the association observed between high socioeconomic status and diagnosed asthma in Mexican American children living in the San Francisco Bay Area.³³ Grineski et al demonstrated that high acculturation, derived from an abbreviated version of the Cultural Life Style Inventory, was significantly associated with asthma in Hispanic youth from El Paso, Texas,³⁴ even after considering neighborhood factors³⁵; however, after accounting for undiagnosed asthma, this association no longer persisted.³⁶ Another study, after accounting for native genetic ancestry, also did not demonstrate an association between acculturation and asthma.³⁷ Given this evidence,

further examination of the relationship between acculturation and asthma is warranted to best understand how this potentially important risk factor operates within and across Latino subgroups.

These studies stress the importance of examining different domains of acculturation and including measures that can co-occur or change with acculturation and provide a better understanding of how acculturation relates to various asthma outcomes across Latino subgroups. In the present study we included Genes-Environment & Admixture in Latino Americans (GALA II) study³⁸ participants and leveraged the ethnic diversity across study sites to (1) examine the association between several acculturation measures with reported asthma diagnosis and lung function among Latino youth, (2) determine whether the association remains after consideration of socioenvironmental factors, and (3) determine whether this association varies according to Latino subgroup.

METHODS

Study population

The GALA II study is a case-control study of asthma in Latino children and adolescents designed to examine the complex genetic and socioenvironmental contributors to asthma prevalence, control, and severity. The study was initiated in 2006, and participants were sampled through community- and clinic-based recruitment at health maintenance organizations and community health clinics from 5 urban study centers across the mainland United States and Puerto Rico (see Table E1 in this article's Online Repository at www.jacionline.org). The current analysis was limited to the 4 urban centers in the mainland United States.

All participants were 8 to 21 years old and had no history of other lung or chronic illnesses (other than atopy and allergy-related diseases in the cases). Within each study center, control subjects were frequency matched by hospital or community clinic site. Those in the third trimester of pregnancy, those with a smoking history of 10 or more pack-years, and current smokers were not eligible (see Table E2 in this article's Online Repository at www.jacionline.org). Trained bilingual interviewers administered comprehensive questionnaires to the parents/caretakers of the participants to collect sociodemographic information, medical histories, and environmental exposure-related information. Interviewers were recruited from the same communities of potential participants and trained to respectfully ascertain sensitive information through questionnaires. Written and age-appropriate informed consent/assent was obtained from all participants and their legal guardians. The University of California, San Francisco, and each study site's institutional review board approved the GALA II protocol (GALA II UCSF-IRB no. 10-00889, reference no. 164561).

Ascertainment of ethnicity

The parents and all 4 grandparents of the participants must have self-identified as Latino to be eligible for the study. Ethnicity was collected through the question "Do you consider yourself Spanish/Hispanic/Latino?" with a "yes/no" choice (if yes, please specify: Mexican, Mexican American, Chicano; Spanish, Hispanic, Latino; Dominican; Cuban; and so forth). Multiple selections were allowed. The participant (or the participant's parents) selected the appropriate answers to all questions for the participant, parents, and grandparents. Responses were used to categorize participants according to their nationality or country of origin subgroup.

Outcome assessment

Asthma status was based on a physician's diagnosis and report of symptoms and medication use within 2 years before recruitment. Eligible control subjects had no reported history of asthma, lung disease, or chronic illness and no reported symptoms of wheezing or shortness of breath when not sick (see

Table E2). Spirometry was conducted with a KoKo PFT Spirometer (nSpire Health, Louisville, Colo), according to American Thoracic Society recommendations.³⁹ All asthma medications were withheld for at least 8 hours before testing.

Pulmonary function, including FEV₁ and bronchodilator response, was assessed only in asthmatic patients. FEV₁ was collected as a standard measurement of airway obstruction. Predicted pulmonary function was calculated based on Hankinson's formulas for Mexican Americans for all Latino participants.⁴⁰ After completing baseline measurements, participants were given 4 puffs of albuterol (90 µg per puff) through a metered-dose inhaler with a spacer, and spirometry was repeated after 15 minutes. Spirometry was repeated a third time after a second dosage of albuterol (2 puffs if <16 years old or 4 puffs if ≥16 years old). We assessed the maximal bronchodilator response by measuring the percentage change in measured FEV₁ before and after albuterol administration by using the postbronchodilator measurement with the greatest change:

Bronchodilator response (Percentage change in FEV₁) = (Post-FEV₁ – Pre-FEV₁)/Pre-FEV₁ × 100.

Exposure assessment

Acculturation was specified by using 4 variables: nativity status, age at immigration to the United States, language acculturation, and generational status.^{16,29,30} Nativity status classified participants on whether they were born in the United States. To account for length of time in the United States, "age at immigration to the US" was specified as follows: "US born," "ages 0-3," "ages 4-9," and "ages 10+."⁴¹

Language acculturation was specified as low, medium, and high to reflect the preferred language spoken at home by the mother and child and the degree of discordance between their preferences: low indicates that the child and mother both preferred Spanish; medium was used when either the child or mother preferred Spanish or neither preferred a primary language; and high was used in instances when 1 person from a mother/child pair preferred English, whereas the other person had a preference to speak English or had no preference.

Generational status is a measure based on the participant's and the parents' country of birth. Participants born outside of the United States were classified as first generation or foreign born, regardless of parents' country of birth, children born in the United States whose parents were both born outside of the United States were classified as second generation, and children born in the United States who had at least 1 parent born in the United States were classified as third generation (see Table E3 in this article's Online Repository at www.jacionline.org). We created a composite acculturation index based on language preference and generation in the United States, whereas participants were categorized as having a high index if they had either high language acculturation or were third generation, medium if they had medium language acculturation and were second generation, and low if they did not fit the above categories (see Table E4 in this article's Online Repository at www.jacionline.org).

Covariate selection

Informed by previous studies, age,⁶ maternal age at birth,⁴² sex,⁴³ socioeconomic status,^{33,44} environmental exposures,⁴⁵⁻⁴⁹ birth weight,^{50,51} and global genetic ancestry^{38,52} were considered potential confounders in the analyses. The socioeconomic indicators included were maternal educational attainment and insurance status. Maternal education, considered a stable measure of socioeconomic status,⁵³ was ascertained as the highest grade level or year completed by the mother and categorized as high/low based on high school graduate status. Health insurance status, a marker of access to health care services,⁵⁴ was ascertained through questionnaire data and categorized as no health insurance, government-subsidized insurance, or privately owned health insurance. Environmental exposures include *in utero* tobacco exposure and report of mold and cockroach exposure; these exposures were collected as present or absent. Low birth weight was a binary variable used to indicate whether participants were less than 5.5 pounds at birth.⁵⁵

Participants were genotyped by using the LAT1 array (World Array 4; Affymetrix, Santa Clara, Calif).³⁸ Estimates of global native and African

genetic ancestry were obtained by using an unsupervised analysis in ADMIXTURE assuming 3 ancestral populations.

For participants with asthma, the brief medication questionnaire⁵⁶ was used to ascertain reported use of controller medications. Use of controller medication was defined as report of inhaled corticosteroid, leukotriene inhibitor, and/or long-acting β-agonist use in the 2 weeks before recruitment.

By July 2014, there were 4702 participants in the GALA II study. Of those, 2578 participants lived in the mainland United States and thus were eligible for the current analysis. Participants were excluded from the analysis if a participant had missing data for child or parent's country of birth (n = 1), self-reported maternal educational level (n = 35), insurance status (n = 29), mold exposure (n = 27), birth weight (n = 356), and/or additional covariate or demographic information (n = 281). Excluded participants were more likely to be older, female, and born outside the United States or to have no health insurance and did not report mold exposure (*P* < .05). Our analytic size included 1849 participants (1136 Mexican American, 193 Central or South American, 302 Caribbean Spanish, and 218 other Latino children). The case-only analytic sample used for lung function analysis included 928 participants.

Statistical analysis

We used χ² tests, *t* tests, and Kruskal-Wallis statistics to determine significant associations of each covariate with case-control status. Using multivariable logistic regression, we first examined for an association between measures of acculturation and asthma diagnosis before and after controlling for age, sex, child's Latino subgroup, region of recruitment, and native and African ancestry (model 1). In the second model we additionally adjusted for maternal education, maternal age at birth, insurance status, *in utero* tobacco exposure, birth weight, breast-feeding, and report of household mold and cockroaches. Pulmonary function models were additionally adjusted for current smokers in the household.

Because previous research showed the prevalence of asthma varies across Latino ethnic groups,^{6,14} we included an interaction term between each measure of acculturation and Latino subgroup in the final models. Among children with asthma, we used linear regression to assess the association of lung function measurements (FEV₁ and bronchodilator response) with the acculturation measures. We then completed 2 subanalyses: (1) we limited the analysis to United States-born participants to determine whether the observed acculturation effects persist, and (2) we examined whether the effects of acculturation differed by atopy status. This second subanalysis was informed by the finding that the risk factors for atopic versus nonatopic asthma differ and might even have opposing associations dependent on atopy status.³³ We used a total IgE level of 100 IU/mL or greater as a proxy for atopic status. All analyses were performed with R 3.3.0 software.⁵⁷

RESULTS

Characteristics of the children and adolescents included in the study are displayed in Table I. When compared with healthy control subjects, participants with asthma were younger, more likely to be male, had mothers with higher levels of education and older maternal age at birth, were less likely to be uninsured, were less likely to have been breast-fed, and were more likely to have mothers who smoked during pregnancy (*P* < .05). Moreover, asthmatic patients were more likely to report exposure of household mold, had lower global native genetic ancestry and greater African genetic ancestry, and were less likely to be born outside of the United States, have immigrated to the United States at an older age, have low language acculturation, and be first generation in the United States compared with participants without asthma (*P* < .001).

Asthma status

Higher levels of acculturation across all 4 variables (nativity status, age at immigration to the United States, language

TABLE I. Selected characteristics of participants in the GALA II study, 2006-2014

	Healthy control subjects	Patients with asthma	P value
No.	897	952	
Age (y), median (IQR)	13.0 (10.6-15.7)	12.0 (9.9-14.5)	<.001
Male sex	382 (42.6)	540 (56.7)	<.001
Ethnicity subgroup			.001
Caribbean Spanish	126 (14.0)	176 (18.5)	
Central American	92 (10.3)	75 (7.9)	
Mexican American	578 (64.4)	558 (58.6)	
South American	15 (1.7)	11 (1.2)	
Other Latino*	86 (9.6)	132 (13.9)	
Mother's education			.016
Less than high school graduate	496 (55.3)	473 (49.7)	
High school graduate or greater	401 (44.7)	479 (50.3)	
Insurance status			<.001
None	76 (8.5)	36 (3.8)	
Government subsidized	704 (78.5)	747 (78.5)	
Private insurance	117 (13.0)	169 (17.8)	
Maternal age at birth (y), median (IQR)	23.0 (20.0-28.0)	25.0 (21.0-29.0)	<.001
Ever breast-fed, yes	704 (78.5)	653 (68.6)	<.001
Weight <5.5 pounds at birth, yes	64 (7.1)	78 (8.2)	.393
In utero tobacco exposure, yes	26 (2.9)	47 (4.9)	.024
Current smokers in household			.796
None	675 (75.3)	740 (77.7)	
1	144 (16.1)	145 (15.2)	
≥2	44 (4.9)	46 (4.8)	
Missing	34 (3.8)	21 (2.2)	
Report of mold exposure, yes	243 (27.1)	352 (37.0)	<.001
Report of cockroach exposure, yes	335 (37.3)	349 (36.7)	.760
Nativity status, born outside the United States	240 (26.8)	110 (11.6)	<.001
Language acculturation†			<.001
Low (Spanish-Spanish)	226 (25.2)	170 (17.9)	
Medium (Spanish-English)	523 (58.3)	490 (51.5)	
High (English-English)	148 (16.5)	292 (30.7)	
Age at immigration (y)			<.001
≥10	63 (7.0)	21 (2.2)	
4-9	107 (11.9)	54 (5.7)	
0-3	70 (7.8)	35 (3.7)	
United States born	657 (73.2)	842 (88.4)	
Generation in the United States			<.001
First	240 (26.8)	110 (11.6)	
Second	521 (58.1)	563 (59.1)	
Third	136 (15.2)	279 (29.3)	
Composite acculturation measure‡			<.001
Low	347 (38.7)	226 (23.7)	
Medium	379 (42.3)	387 (40.7)	
High	171 (19.1)	339 (35.6)	
Study site			.192
Chicago	217 (24.2)	233 (24.5)	
New York	220 (24.5)	245 (25.7)	
San Francisco	337 (37.6)	318 (33.4)	
Texas	123 (13.7)	156 (16.4)	
Native ancestry (%), median (IQR)	53.9 (38.2-71.2)	48.9 (25.3-61.4)	<.001
African Ancestry (%), median (IQR)	5.0 (3.0-9.0)	5.8 (3.6-13.1)	<.001
Spirometry, mean (SD)			
FEV ₁ (% predicted)	—	94.2 (14.5)	
Missing, no. (%)	—	22 (2.3)	
Bronchodilator response (% change)	—	9.5 (8.8)	
Missing, no. (%)	—	24 (2.5)	
Controller medication use, yes*	—	396 (41.6%)	

Results are presented as numbers (percentages), unless otherwise noted. *P* values are from χ^2 and Kruskal-Wallis tests.

IQR, Interquartile range.

*Includes those who identify as more than 1 Latino subgroup or as Spanish.

†Language acculturation describes the concordance between the mother and child's language preference. If both prefer Spanish, they have low language acculturation, and if both prefer English, they have high language acculturation.

‡Controller medication includes yes/no responses to leukotriene inhibitor, inhaled corticosteroid, long-acting bronchodilator, or combination therapy.

preference, and generational status) were associated with increased odds of asthma when compared with the lowest category, even after adjusting for socioenvironmental factors (Fig 1 and Table II). In the fully adjusted model United States–born participants were 2.10 (95% CI, 1.60–2.77) times more likely to have asthma compared with those born outside the United States. Similarly, child–mother dyads who preferred English as their primary language had 2.20 (95% CI, 1.54–3.14) greater odds of asthma compared with those who preferred Spanish. In addition, United States–born participants had 2.47 (95% CI, 1.46–4.33) times odds of asthma compared with subjects who moved to the United States after age 10 years. No significant association was observed among participants who immigrated to the United States at an age of less than 10 years. We found 1.94 (95% CI, 1.47–2.57) and 2.94 (95% CI, 2.06–4.22) greater odds of asthma among second- and third-generation participants, respectively, compared with first-generation subjects. When we examined the relationship using a composite measure of acculturation, we found 1.49 (95% CI, 1.17–1.92) and 2.43 (95% CI, 1.78–3.34) higher odds of asthma in those with a medium and high acculturation index score, respectively, compared with those with a low index score. No significant changes were observed when analyses were adjusted for total IgE levels in participants with available data (see Table E5 in this article's Online Repository at www.jacionline.org) nor was a significant interaction observed with high/low total IgE levels (all $P > .14$).

Lastly, when associations were limited to United States–born participants, greater levels of acculturation were associated with asthma diagnosis compared with children with low acculturation (see Table E6 in this article's Online Repository at www.jacionline.org). We did not find evidence for these associations to vary by self-reported Latino subgroup because each of the interaction terms between each acculturation variable and Latino subgroup were not significant ($P > .09$, see Table E7 in this article's Online Repository at www.jacionline.org).

Pulmonary function

When we examined the association between each acculturation variable and pulmonary function measures (FEV₁ and bronchodilator response), we found greater FEV₁ percentages in child–mother dyads who preferred English compared with child–mother dyads who preferred Spanish (3.70%; 95% CI, 0.56% to 6.84%). A high acculturation index was also associated with greater FEV₁ percentages when compared with a low acculturation index (3.59%; 95% CI, 0.77% to 6.41%; Table III). Compared with child–mother dyads who preferred Spanish exclusively, we observed lower bronchodilator response among dyads discordant for language preference (–1.98%; 95% CI, –0.34% to –3.62%) and dyads who preferred English (–3.05%; 95% CI, –1.05% to –5.06%; Table IV). We also found a lower bronchodilator response among participants with a high acculturation index (–3.23%; 95% CI, –1.44% to –5.03%) compared with those with a low acculturation index. Nativity status, age moved to the United States, and generation status in the United States were not associated with pulmonary function measures. No significant changes were observed when analyses were adjusted for total IgE levels in participants with available data (see Table E5) nor was there a significant interaction observed with high/low total IgE levels ($P > .36$). Among United States–born participants, significant associations between acculturation measures and

diagnosed asthma persisted; additionally, we observed that language acculturation, generation in the United States, and the composite acculturation index were associated with greater FEV₁ (see Table E6).

DISCUSSION

Our findings show that regardless of acculturation definition, we consistently observed that greater acculturation (ie, United States born, moving to the United States at an earlier age, English language preference, and third generation in the United States) was associated with greater odds of asthma. These findings remained robust, even after adjusting for social (socioeconomic status, history of breast-feeding, and birth weight), environmental (*in utero* tobacco and reported mold and cockroach exposure), and genetic factors that have been postulated to explain this association. Our findings are consistent with past research examining the role of acculturation in Mexican Americans^{17–19} and in other ethnic groups,^{14,41} as well as building on findings demonstrating that with increased length of stay in the United States, the odds of asthma in Latino populations also increases.

Low acculturation in Latino populations has been consistently associated with better health for several outcomes,^{11,58} suggesting certain cultural and behavioral practices and community networks, leading to increased disease risk. For instance, obesity, low birth weight, smoking, and reduction in breast-feeding are more common among highly acculturated subjects compared with recent immigrants,^{25,26,58–60} each of these factors being an independent risk factor for asthma.^{47,48,50,51,61}

This study is one of few studies to examine the association between acculturation and pulmonary function measurements in Latinos. Across most measures of acculturation, we did not observe a significant association with bronchodilator response or FEV₁. An exception was with language preference, where we observed that higher levels of language acculturation were associated with lower bronchodilator response and greater FEV₁. These findings raise 2 potential hypotheses.

The first, aligning with our findings that greater levels of acculturation were associated with higher odds of asthma, is that the psychosocial stress related to acculturation might not only increase risk for disease but also decrease drug response to traditional asthma therapies. Language preference might better reflect the cultural and behavioral aspects of acculturation than the other measures used in this study. Past research suggests that acculturative stress can manifest physiologically with psychosomatic symptoms.⁶² This finding of lower bronchodilator response is consistent with previous research associating high stress levels with lower bronchodilator response.⁶³ However, this would not account for the finding of higher FEV₁ in the more acculturated groups.

A second hypothesis, contrary to our case-control findings, is that English language preference results in improved asthma control manifesting as decreased bronchodilator response (already at personal best)⁶⁴ and greater FEV₁ compared with that in children with low language acculturation. This is consistent with previous studies demonstrating that high language concurrence with a medical provider results in improved asthma control in Latinos.^{65,66} However, these findings warrant further investigation.

Our study has several limitations, and results should be interpreted within the context of these limitations. Sample sizes

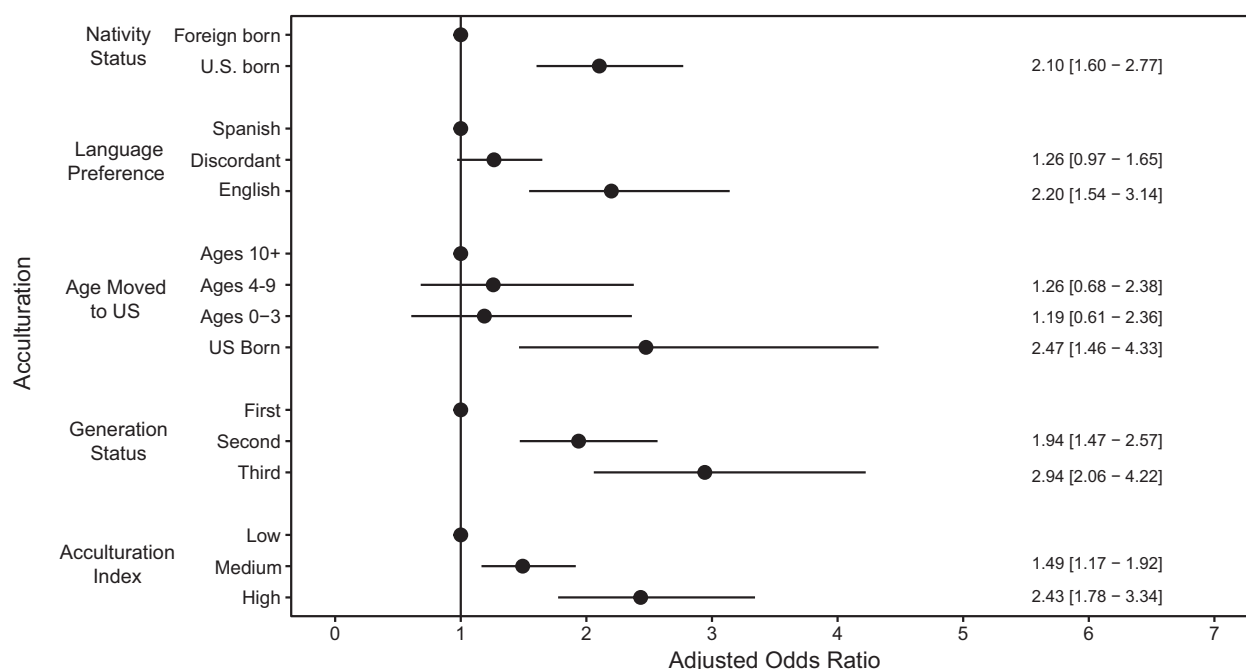


FIG 1. Adjusted odds of having asthma with acculturation measures (nativity status, age moved to United States, language preference, and generational status) for participants from the GALA II study, 2006-2014. Models adjusted for age, sex, *in utero* tobacco exposure, maternal education, maternal age at birth, insurance status, report of household mold and cockroaches, breast-feeding, birth weight, study site, global African and native genetic ancestry, and child's Latino subgroup.

TABLE II. Estimated odds ratios and 95% CIs of diagnosed asthma for acculturation measures in the GALA II study, 2006-2014

Acculturation measure	Unadjusted (95% CI)	Model 1* (95% CI)	Model 2† (95% CI)
Nativity			
Not born in the United States	Reference	Reference	Reference
Born in the United States	2.80 (2.19-3.59)	2.38 (1.84-3.10)	2.10 (1.60-2.77)
Language acculturation			
Low (Spanish-Spanish)	Reference	Reference	Reference
Medium (Spanish-English)	1.25 (0.99-1.58)	1.34 (1.04-1.73)	1.26 (0.97-1.65)
High (English-English)	2.62 (1.98-3.48)	2.32 (1.68-3.23)	2.20 (1.54-3.14)
Age at immigration (y)			
≥10	Reference	Reference	Reference
4-9	1.51 (0.85-2.78)	1.24 (0.68-2.31)	1.26 (0.68-2.38)
0-3	1.50 (0.80-2.87)	1.16 (0.60-2.28)	1.19 (0.61-2.36)
United States born	3.84 (2.36-6.51)	2.76 (1.66-4.77)	2.47 (1.46-4.33)
Generation in United States			
First	Reference	Reference	Reference
Second	2.36 (1.83-3.05)	2.19 (1.68-2.87)	1.94 (1.47-2.57)
Third	4.48 (3.31-6.09)	3.37 (2.40-4.76)	2.94 (2.06-4.22)
Acculturation index			
Low	Reference	Reference	Reference
Medium	1.57 (1.26-1.95)	1.68 (1.32-2.13)	1.49 (1.17-1.92)
High	3.04 (2.38-3.91)	2.68 (2.00-3.60)	2.43 (1.78-3.34)

*Model 1 was adjusted for age, sex, child's Latino subgroup, Native and African ancestry, and study site.

†Model 2: model 1 with additional adjustment for maternal education, maternal age at birth, insurance status, *in utero* tobacco exposure, breast-feeding, birth weight, report of mold, and report of cockroaches.

for non-Mexican American populations in our study are small. Although we did not observe an interaction, the overall results should be interpreted with caution.

A second limitation is the lack of consideration of obesity as a potential explanatory pathway for the association between asthma and higher acculturation.^{58,67} We were unable to assess this

relationship because body mass index information was missing on more than 40% of healthy control subjects. The lack of controlling for body mass index might have attenuated our results.

We were also unable to account for air pollution effects because of a lack of accurate estimates for participants born outside of the United States (in total, missing data for 35% of study population).

TABLE III. Estimated FEV₁* percent predicted mean difference and 95% CIs for acculturation measures in participants with asthma from the GALA II study, 2006-2014 (n = 931)

Acculturation measure	Unadjusted mean difference (95% CI)	Model 1,* mean difference (95% CI)	Model 2,† mean difference (95% CI)
Nativity			
Not born in the United States	Reference	Reference	Reference
Born in the United States	0.63 (−2.28 to 3.54)	2.37 (−0.42 to 5.16)	2.35 (−0.51 to 5.22)
Language acculturation			
Low (Spanish-Spanish)	Reference	Reference	Reference
Medium (Spanish-English)	0.63 (−1.92 to 3.18)	2.13 (−0.38 to 4.63)	1.73 (−0.84 to 4.31)
High (English-English)	−1.82 (−4.59 to 0.94)	3.52 (0.60 to 6.44)	3.70 (0.56 to 6.84)
Age at immigration *(y)			
≥10	Reference	Reference	Reference
4-9	0.99 (−6.33 to 8.30)	0.33 (−6.53 to 7.20)	0.06 (−6.89 to 7.01)
0-3	1.89 (−6.05 to 9.83)	−0.22 (−7.71 to 7.26)	−0.72 (−8.27 to 6.84)
United States born	1.70 (−4.59 to 7.98)	2.47 (−3.49 to 8.43)	2.16 (−3.86 to 8.17)
Generation in the United States			
First	Reference	Reference	Reference
Second	1.77 (−1.20 to 4.75)	2.15 (−0.69 to 4.99)	2.11 (−0.82 to 5.03)
Third	−1.68 (−4.90 to 1.53)	3.06 (−0.21 to 6.32)	3.10 (−0.28 to 6.48)
Acculturation index			
Low	Reference	Reference	Reference
Medium	0.20 (−2.20 to 2.61)	1.65 (−0.70 to 3.99)	1.30 (−1.12 to 3.71)
High	−1.94 (−4.40 to 0.53)	3.50 (0.85 to 6.14)	3.59 (0.77 to 6.41)

*Model 1 was adjusted for age, sex, child's Latino subgroup, controller medication use, Native and African ancestry, and study site.

†Model 2: model 1 with additional adjustment for maternal education, maternal age at birth, insurance status, *in utero* tobacco exposure, current smokers in household, breast-feeding, birth weight, report of mold, and report of cockroaches.**TABLE IV.** Estimated bronchodilator response (as a percentage): Mean difference and 95% CI for acculturation measures in participants with asthma from the GALA II study, 2006-2014 (n = 931)

Acculturation measure	Unadjusted mean difference (95% CI)	Model 1,* mean difference (95% CI)	Model 2,† mean difference (95% CI)
Nativity			
Not born in the United States	Reference	Reference	Reference
Born in the United States	0.05 (−1.72 to 1.82)	−0.47 (−2.26 to 1.32)	−0.05 (−1.89 to 1.78)
Language acculturation			
Low (Spanish-Spanish)	Reference	Reference	Reference
Medium (Spanish-English)	−2.32 (−3.87 to −0.77)	−2.20 (−3.80 to −0.60)	−1.98 (−3.62 to −0.34)
High (English-English)	−2.44 (−4.12 to −0.76)	−3.41 (−5.27 to −1.55)	−3.05 (−5.06 to −1.05)
Age at immigration			
≥10	Reference	Reference	Reference
4-9	3.55 (−0.91 to 8.00)	3.31 (−1.09 to 7.70)	3.24 (−1.21 to 7.68)
0-3	1.89 (−2.94 to 6.73)	1.66 (−3.13 to 6.45)	1.65 (−3.19 to 6.48)
United States born	2.40 (−1.43 to 6.23)	1.69 (−2.12 to 5.51)	2.05 (−1.79 to 5.90)
Generation in the United States			
First	Reference	Reference	Reference
Second	0.21 (−1.62 to 2.03)	−0.02 (−1.83 to 1.80)	0.38 (−1.49 to 2.25)
Third	−0.27 (−2.25 to 1.70)	−1.89 (−3.98 to 0.20)	−1.39 (−3.55 to 0.77)
Acculturation index			
Low	Reference	Reference	Reference
Medium	−1.81 (−3.27 to −0.34)	−1.83 (−3.32 to −0.33)	−1.54 (−3.08 to 0.00)
High	−2.14 (−3.64 to −0.64)	−3.59 (−5.27 to −1.90)	−3.23 (−5.03 to −1.44)

*Model 1 was adjusted for age, sex, child's Latino subgroup, controller medication use, Native and African ancestry, and study site.

†Model 2: model 1 with additional adjustment for maternal education, maternal age at birth, insurance status, *in utero* tobacco exposure, current smokers in household, breast-feeding, birth weight, report of mold, and report of cockroaches.

However, we were able to account for indoor air pollutant sources, including reports of mold, cockroaches, and *in utero* tobacco smoke exposure.

Another limitation might be underdiagnosis among our healthy control population. Subjects with low educational attainment, especially immigrant Latinos, have a poor rate of enrollment in

insurance programs.⁶⁸ The Latino population is underinsured compared with other racial/ethnic groups. For example, Mexican American children aged 18 years or younger have a 16% uninsured rate compared with the national average of 10%.⁶⁹ Because minority health is often shaped by language barriers, access to preventive care, and lack of health insurance, limiting the ability

to navigate the health care system and poor patient-provider communication, underdiagnosis cannot be ruled out in this population.^{36,70} Outcome misclassification was minimized in our study by carefully screening healthy control subjects for any asthma-related symptoms using the questions following the International Study of Asthma and Allergies in Childhood screening tool; however, we acknowledge that terms such as “wheezing” and “whistling” can get lost in translation.

In conclusion, we found that the odds of asthma increase as acculturation increases for Latino children, regardless of how acculturation was defined. The direction of this association remained robust for all national subgroups, raising its importance as a risk factor that necessitates future study to identify important and modifiable risks for asthma in this high-risk population.

We acknowledge the families and patients for their participation and thank the numerous health care providers and community clinics for their support and participation in the GALA II study. In particular, we thank study coordinator Sandra Salazar and the recruiters who obtained the data: Duanny Alva, MD; Gaby Ayala-Rodriguez; Ulysses Burley; Lisa Caine; Elizabeth Castellanos; Jaime Colon; Denise DeJesus; Iliana Flexas; Blanca Lopez; Brenda Lopez, MD; Louis Martos; Vivian Medina; Juana Olivo; Mario Peralta; Esther Pomares, MD; Jihan Quraishi; Johanna Rodriguez; Shahdad Saeedi; Dean Soto; Ana Taveras; and Emmanuel Viera.

Key messages

- Regardless of the acculturation measure used, we observed lower odds of asthma with lower acculturation (ie, born outside the United States, moving to the United States at an older age, language preference, and first generation in the United States), even after adjustment for important socioenvironmental factors.
- Among children with asthma, Spanish language preference was associated with lower FEV₁ and increased bronchodilator response, an important indicator of asthma control.

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