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Authors
Oh, Sam S
Du, Randal
Zeiger, Andrew M
et al.

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Breastfeeding associated with higher lung function in African American youths with asthma.

Sam Oh, PhD, MPH,
University of California San Francisco, Medicine, Box 2911, San Francisco, 94143-2911 United States

Dr Randal Du,
University of California San Francisco, Medicine, 1001 Potrero Ave, San Francisco, 94143 United States

University of California San Francisco, Pharmacy, Box 2911, San Francisco, 94143-2911 United States

Mr Andrew M Zeiger,
University of California San Francisco, Medicine, 1001 Potrero Ave, San Francisco, 94110 United States

Dr Meghan E Mcgarry, MD, MAS,
University of California San Francisco, Pediatrics, 550 16th Street, 5th Floor, San Francisco, 94158 United States

Dr Donglei Hu, PhD,
University of California San Francisco, Medicine, San Francisco, 94143 United States

Neeta Thakur, MD, MPH,
University of California San Francisco, Medicine, Box 2911, San Francisco, 94143-2911 United States

Dr Maria Pino-Yanes, PhD,
Hospital Universitario NS de Candelaria, Research Unit, Carretera del Rosario, 145, Spain

Joshua M. Galanter, MD, MAS,
University of California San Franscisco, Bioengineering and Therapeutic Sciences, United States

University of California San Francisco, Medicine, Box 2911, San Francisco, 94143-2911 United States

Celeste Eng,

(Corresponding Author) Sam Oh, PhD, MPH, Sam.Oh@ucsf.edu, University of California San Francisco, Medicine, Box 2911, San Francisco, 94143-2911 United States. randaldu@gmail.com, andrew.zeiger@ucsf.edu, meghan.mcgarry@ucsf.edu, donglei.hu@ucsf.edu, neeta.thakur@ucsf.edu, mdelpino@ull.edu.es, joshua.galanter@ucsf.edu, celeste.eng@ucsf.edu, knishimura@gmail.com, scott.huntsman@ucsf.edu, hjfarber@texaschildrens.org, kmeade@mail.cho.org, pavila2016@gmail.com, denise.serebrisky@nbhn.net, kirsten.bibbins-domingo@ucsf.edu, drlenoir@drlenoir.com, jford@jhsph.edu, emerita.buenaventura@nsmtp.kp.org, william.rodriguez@va.gov, sthyne@mednet.ucla.edu, sen@uthsc.edu, jr@pedasthma.com, KWILLIA5@hfhs.org, rkumar@luriechildrens.org, esteban.burchard@ucsf.edu.

Declaration of Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

University of California San Francisco, Medicine, San Francisco, 94143 United States

Dr Katherine Keiko Nishimura, PhD, MPH,
University of California San Francisco, Medicine, 1001 Potrero Ave, San Francisco, 94143 United States

Mr Scott Huntsman,
University of California San Francisco, Medicine, Box 2911, San Francisco, 94143-2911 United States

Harold J. Farber, MD, MSPH,
Baylor College of Medicine, Pediatrics, Houston, 77030-3411 United States

Texas Children's Hospital, Pulmonology, Houston, 77030 United States

Dr Kelley Meade, MD,
UCSF Benioff Children's Hospital, Primary Care, San Francisco, 94143 United States

Dr Pedro Avila,
Northwestern, Medicine, United States

Denise Serebrisky, MD,
Jacobi Medical Center, Pediatric Pulmonology, Bronx, 10461-1197 United States

Dr Kirsten Bibbins-Domingo,
University of California San Francisco, Medicine, San Francisco, 94143 United States

Dr Michael A. Lenoir,
Bay Area Pediatrics, Pediatrics, Oakland, United States

Jean G. Ford, MD,
Johns Hopkins University Bloomberg School of Public Health, Epidemiology, Baltimore, 21205-2103 United States

Dr Emerita Brigino-Buenaventura,
Kaiser Permanente Vallejo Medical Center, Allergy and Immunology, San Francisco, 94110 United States

Dr William Rodriguez-Cintron, MD,
VA Caribbean Healthcare System, Pulmonary/Critica Care, Calle Casia #10, San Juan, oo921 Puerto Rico

Dr Shannon M. Thyne, MD,
University of California Los Angeles David Geffen School of Medicine, Medicine, Los Angeles, United States

Dr Saunak Sen, PhD,
University of California San Francisco, Epidemiology and Biostatistics, San Francisco, 94110 United States

Jose R. Rodriguez-Santana, MD,
Centro de Neumología Pediátrica, Pediatric Pulmonology and Critical Care, United States

Keoki Williams, MD, PhD,

Henry Ford Health System, Center for Health Policy and Health Services Research, Detroit, 48202-3450 United States

Henry Ford Health System, Internal Medicine, Detroit, 48202-3450 United States

Dr Rajesh Kumar, and
Northwestern University, Medicine, Evanston, 60208-0001 United States

Esteban G. Burchard, MD, MPH
University of California San Francisco, Medicine, Box 2911, San Francisco, 94143-2911 United States

University of California San Francisco, Bioengineering and Therapeutic Sciences, Box 2911, San Francisco, 94143-2911 United States

Abstract

Objective—In the United States, Puerto Ricans and African Americans have lower prevalence of breastfeeding and worse clinical outcomes for asthma compared with other racial/ethnic groups. We hypothesize that history of breastfeeding is associated with increased forced expiratory volume in 1 second (FEV_1) % predicted and reduced asthma exacerbations in Latino and African American youths with asthma.

Methods—As part of Study A and Study B, we conducted case-only analyses in children and adolescents aged 8–21 years old with asthma from four different racial/ethnic groups: African Americans (n=426), Mexican Americans (n=424), mixed/other Latinos (n=255), and Puerto Ricans (n=629). We investigated the association between any breastfeeding in infancy and FEV_1 % predicted as well as asthma exacerbations using multivariable linear and Poisson regression models, respectively.

Results—Prevalence of breastfeeding was lower in African Americans (59.4%) and Puerto Ricans (54.9%) compared to Mexican Americans (76.2%) and mixed/other Latinos (66.9%; $p<0.001$). After adjusting for covariates, breastfeeding was associated with a 3.58 percentage point increase in FEV_1 % predicted ($p = 0.01$) and a 21% reduction in asthma exacerbations ($p = 0.03$) in African Americans only.

Conclusion—Breastfeeding was associated with higher FEV_1 % predicted in asthma and reduced number of asthma exacerbations in African American youths, calling attention for continued support for breastfeeding

Keywords

asthma; breastfeeding; genetic admixture; Hispanics; minority; lung function; exacerbations

Introduction

Asthma is the most common chronic disease in children, with a reported prevalence of 9.5% among all children aged 0–17 in the United States (1). However, asthma prevalence varies greatly by race and ethnicity in the United States, and the racial/ethnic disparity has been worsening over time (1). Asthma is most prevalent among Puerto Ricans (36.5%),

intermediate among African Americans (13.0%) and non-Hispanic Whites (12.1%), and least common among Mexican Americans (7.5%) (2). Furthermore, overall asthma mortality is up to four times as high in African Americans and Puerto Ricans compared to Mexican Americans and non-Hispanic whites (3,4).

Evidence regarding the benefit of breastfeeding on lung function and asthma has been conflicting (5–10). However, a recent meta-analysis demonstrated that breastfeeding is associated with reduced asthma/wheeze risk in children between 0–2 years of age (7). Breastfeeding has been associated with increased forced expiratory volume in 1 second (FEV_1)—defined as the volume of air expelled during the first second in forced expiration—in children of mothers with asthma (8) and has also been associated with lower incidence of wheezing among toddlers (9).

In addition to equivocal literature support for breastfeeding as a protective factor in reducing asthma risk (7), few current studies examining the relationship between breastfeeding and asthma primarily focus on populations in which breastfeeding prevalence is low. For instance, recent estimates indicate that Puerto Rican and African American women are less likely to breastfeed than other racial and ethnic groups in the United States (11,12). Furthermore, to our knowledge, no studies with sufficient minority representation (i.e., >25% non-Hispanic white) (13) have examined the association between breastfeeding and lung function, nor the relationship between breastfeeding and asthma exacerbations in African American and Latino youth with asthma.

We aim to examine the relationship of breastfeeding with lung function and asthma exacerbations in Latino and African American youths with asthma who (1) share a disproportionate burden of health inequities (3) and (2) are underrepresented in biomedical literature (13). Furthermore, because of the disparity in asthma prevalence and mortality between different races and ethnicities—indeed, even within Latinos (2,3)—we aim to examine these relationships within each group. We hypothesize that breastfeeding is associated with increased FEV_1 percent predicted and with decreased asthma exacerbations among African American and Latino subgroup youths with asthma.

Methods

Participant Recruitment and Design

The study participants were recruited as part of Study A and Study B, ongoing multicenter studies with current recruitment of 2308 Latino and 902 African American participants with asthma (14). Both studies were conducted in parallel, using the same recruitment and data collection protocols. Recruitment was performed across the mainland United States (Chicago, Illinois; Bronx, New York; Houston, Texas; and San Francisco Bay Area, California) and Puerto Rico for Study A and in the San Francisco Bay Area, California for Study B. We recruited participants with physician-diagnosed asthma aged 8 to 21 years of African American or Latino descent. Asthma status was defined by physician diagnosis of asthma as well as having at least 2 or more symptoms of coughing, wheezing, or shortness of breath in the 2 years prior to recruitment. Participants were excluded from enrollment if they reported at least 10 pack-years of smoking or a history of any smoking in the year

preceding enrollment, pregnancy in the third trimester, any asthma exacerbations or respiratory infections in the 6 weeks before recruitment, any chronic lung conditions other than asthma, or history of one of the following conditions: sickle cell disease, cystic fibrosis, sarcoidosis, cerebral palsy, or history of heart or chest surgery.

Participants must have self-identified as African American or Latino and had four African American or Latino grandparents. Latino participants were further categorized as Mexican American, Puerto Rican, or mixed/other Latino based on self-reported ethnicity or country of origin. Institutional review board approval was obtained in each of the participating facilities. Consent was given by the participant or by the participant and the participant's parent or legal guardian if the participant was under 18 years of age at recruitment.

We administered a face-to-face questionnaire to each participant or his/her legal guardian if the participant was less than 18 years old. Bilingual interviewers, fluent in English and Spanish, were utilized to reduce the risk of language barriers affecting response to the questionnaire. The questionnaire also inquired about family members' medical history, income, education level, insurance status, and environmental factors such as prenatal and current household smoking.

Breastfeeding

Breastfeeding was recorded as a dichotomous variable. Interviewers asked the question "Were you ever breastfed?" or "Was the child ever breastfed?" as part of the questionnaire. A positive answer was considered confirmation of any breastfeeding in infancy.

Outcomes

The primary outcome was the volume of air a participant could forcibly exhale in one second (FEV_1) divided by the FEV_1 that would be expected based on the participant's age, sex, height, and race. We refer to this proportion as FEV_1 percent (%) predicted, which was normally distributed in each of our study populations. An individual's predicted FEV_1 was determined from standardized lung function prediction equations as developed by Hankinson et al. in 1999 (15). Pulmonary function equations used for calculating predicted FEV_1 in our analysis rely on specific racial/ethnic groups, for which there are three reference equations: non-Hispanic white, African (used for the African American group) and Mexican American (used for all Latino groups). Spirometry for participants was performed according to American Thoracic Society and European Respiratory Society standards (16) using a KoKo® PFT Spirometer (nSpire Health Inc., Louisville, Colorado).

To study clinically relevant asthma outcomes, we examined the association between breastfeeding and asthma exacerbations, as defined under American Thoracic Society criteria (17). Consistent with a previous study (18), we examined asthma exacerbations though a combination of the following indicators: self-reported asthma-related hospitalizations, emergency department visits, and oral corticosteroid use. We constructed an exacerbation "score" by summing the number of asthma-related hospitalizations, emergency department visits, and instances of oral corticosteroid use (one point for any use, two points for continued use beyond 2 weeks) over the past year. The exacerbation score ranged from 0 to 10 in our study population.

Covariates

Covariate selection was based upon significant associations between both breastfeeding and lung function or asthma risk, either consistent with previous studies (19–21) or our population. We included in our analysis proportion of Native American ancestry (ranging from 0 to 1) for Study A (20), proportion of African ancestry (ranging from 0 to 1) (19), body mass index (BMI) category (22), socioeconomic status (23), total immunoglobulin E (IgE) levels (24,25), family history of asthma (26), chest illnesses before age 2 (27), maternal prenatal smoking (28), birth weight (28,29), recruitment center (representative of geographic location) (30) and sex (21).

Genetic ancestry for African Americans and Latinos is admixed, with different levels of European and African ancestry in African Americans, and European, African, and Native American ancestry in Latinos (31). As pulmonary function prediction equations may be inaccurate in racially admixed populations (19), and since breastfeeding was empirically associated with ancestry in our study population, we included measures of genetic ancestry as a covariate in our statistical models. Estimates of African, European, and Native American ancestry were based on genome-wide genotyping data using the program ADMIXTURE (32) assuming 3- and 2-population models for Study A and Study B, respectively.

BMI was calculated by dividing a participant's weight in kilograms by the square of their height in meters (33). If the participant was under the age of 18, BMI percentile was calculated according to age and sex (34,35). BMI was then categorized into four groups based on Centers for Disease Control and Prevention (CDC) criteria: underweight (BMI $<5^{th}$ percentile), normal weight (BMI 5^{th} to $<85^{th}$ percentile), overweight (BMI 85^{th} to $<95^{th}$ percentile), and obese (BMI 95^{th} percentile or higher) (33). For participants over the age of 18, BMI was categorized as: underweight (BMI<18.5), normal weight (BMI 18.5 to <25), overweight (BMI 25 to <30), or obese (BMI 30 or higher) (33).

Socioeconomic status (SES) was determined based on the following indicators: reported household income, maternal education level, and health insurance status (36). Income was divided into tertiles for each recruitment center, then ranked (1 = lowest tertile, 3 = highest tertile). Maternal education and health insurance status were each ranked into three ordinal categories (1 = lowest, 3 = highest). The individual SES indicators were summed together to create an overall SES score.

Total serum IgE levels were measured on the ImmunoCAP™ 100 system (Phadia, Kalamazooo, MI) (37).

Information about family history of asthma, chest illnesses before age 2, and maternal prenatal smoking was ascertained through separate interview questions. Participants were considered to have been "exposed" if they answered positively when asked if (1) his/her mother or father had ever been diagnosed with asthma, (2) whether he/she had ever been seen by a doctor or health care provider for a chest illness before the age of 2 years, or (3) if his/her mother smoked while pregnant with him/her.

Of 3210 eligible participants, participants were excluded based on missing or unknown data for African ancestry (627), income (413), IgE (150), birthweight (103), FEV_1 % predicted (64), breastfeeding (41), family history of asthma (19), chest illness before age 2 (19), insurance status (15), maternal prenatal smoking (13), maternal education (9), and BMI category (3). These exclusions yielded an analytical sample of 1734 participants: 426 African Americans, 424 Mexican Americans, 255 mixed/other Latinos, and 629 Puerto Ricans. Subjects with incomplete data were more likely to have lower birth weight ($p = 0.01$), have exposure to prenatal maternal smoking ($p = 0.003$), be older ($p<0.001$), be female ($p<0.001$), and less likely to have chest illness before age 2 ($p = 0.005$). Participants recruited in Puerto Rico were more likely to have incomplete data compared to participants recruited in the United States mainland ($p<0.001$).

Statistical Analysis

Differences in baseline study characteristics by breastfeeding in each racial/ethnic group (African Americans, Mexican Americans, mixed/other Latinos and Puerto Ricans) were assessed by Mann-Whitney U or chi-square tests. Multivariable linear regression was used to estimate the effect of breastfeeding on FEV_1 % predicted before and after adjusting for covariates. To assess the association between breastfeeding and asthma exacerbations, we performed Poisson regression to estimate prevalence ratios. Statistical analysis was performed with R version 3.1.0 (38).

Results

Baseline characteristics by breastfeeding and race/ethnicity are shown in Table 1. Prevalence of breastfeeding was 59.4% in African Americans, 76.2% in Mexican Americans, 66.9% in mixed/other Latinos, and 54.9% in Puerto Ricans ($p<0.001$). Among African Americans, breastfed participants were more likely than non-breastfed participants to be male ($p = 0.01$), have higher SES score ($p<0.001$), and higher birth weight ($p = 0.003$), and less likely to be exposed to prenatal maternal smoking ($p = 0.008$). Among Puerto Ricans, breastfeeding was associated with higher SES score ($p<0.001$). Among mixed/other Latinos, breastfeeding was associated with lower SES score ($p = 0.007$), lower African ancestry ($p = 0.002$), and higher birth weight ($p = 0.04$).

Spirometry Performance

Among African Americans, FEV_1 % predicted was 4.05 percentage points higher among those who were breastfed compared to non-breastfed (Table 2). After adjustment for sex, socioeconomic status, maternal prenatal smoking, BMI category, pulmonary illnesses before age 2, total IgE levels, birth weight, family history of asthma, and proportion of African ancestry, breastfeeding was associated with a 3.58 (95% CI: 0.72 – 6.44) percentage point increase in FEV_1 % predicted among African Americans (Figure 1 and Table 2). This association was not observed in any of the Latino subgroups.

Asthma Exacerbations

Among African Americans, prevalence of asthma exacerbations was 28% lower in breastfed participants compared to non-breastfed participants (PR = 0.72, 95% CI: 0.61 – 0.86, Table

3). After adjustment for sex, socioeconomic status, maternal prenatal smoking, BMI category, pulmonary illnesses before age 2, total IgE levels, birth weight, family history of asthma, and proportion of African ancestry in a multivariable Poisson regression model, breastfeeding was associated with a 21% reduction in asthma exacerbations among African Americans (PR = 0.79, 95% CI: 0.64 – 0.98). In addition, we observed a non-significant association between breastfeeding and each component of asthma exacerbations among African Americans (data not shown). No significant association between breastfeeding and asthma exacerbations was observed in any of the Latino subgroups.

Discussion

In this study, we identify protective effects of breastfeeding on lung function and asthma exacerbations in African American children and adolescents with asthma. In our adjusted analysis, breastfeeding was associated with higher lung function and with a lower exacerbation score in African American children and adolescents with asthma.

Our results are consistent with other studies (7,8,39,40) featuring non-Hispanic whites, which support breastfeeding as a positive influence on lung development in children and young adolescents. However, our study expands upon current literature by examining among minority children the association of breastfeeding with lung function and asthma exacerbations. Additionally, our analysis adjusts for the potential confounding effects of genetic ancestry, which has been shown to influence lung function (19,20), and focuses on populations that are frequently underrepresented in biomedical literature, an important factor in current health disparities (13). To our knowledge, this is the first study to examine and identify an association between breastfeeding and FEV_1 % predicted as well as asthma exacerbations in African Americans. As our findings varied by ethnic/racial group, our analysis underscores the importance of including non-Europeans in biomedical research, and studying each race or ethnicity as a separate subgroup.

From a public health standpoint, our results have important implications in educational efforts to increase rates of breastfeeding. Incremental costs of asthma were estimated to be $56 billion in the United States in 2007 (41). In African Americans, breastfeeding rates are lower than other populations in the United States (12) while asthma prevalence, morbidity, and mortality are among the highest (3,42). Furthermore, healthcare facilities in areas with higher proportions of African Americans are less likely to implement practices that encourage breastfeeding initiation (43). Our results underscore the importance of reducing this disparity and removing the barriers to breastfeeding. Puerto Ricans had the lowest prevalence of breastfeeding and the most asthma exacerbations in our study population, which is consistent with national data on asthma morbidity (2,44). We did not observe a statistically significant association between breastfeeding and lung function among Puerto Ricans but the point estimate (1.53) was in the same direction as the African American point estimate (3.58), and the majority of the 95% confidence interval (−0.93, 3.98) was consistent with an improvement in FEV_1. It is possible that the beneficial effect of breastfeeding may have been overshadowed by other factors associated with a more severe asthma phenotype among Puerto Ricans. For example, Puerto Ricans had substantially higher total IgE levels than any other group in our study population, and higher levels of IgE have been shown to

be associated with lower lung function (FEV_1) (45,46). Alternatively, differences in medical practices and reimbursement schedules may explain a portion of the differences between Puerto Ricans and African Americans.

While a 3.58 percentage point increase in FEV_1 % predicted is within the margin of error in spirometry performance for a single individual, our results indicate that encouragement of breastfeeding can positively shift the distribution of lung function among African Americans with asthma and reduce events related to asthma exacerbations at the population level. Furthermore, the 3.58% gain in FEV_1 % predicted we found associated with breastfeeding is comparable to the effect of long-term air quality improvements on lung function (47). In the report by Gauderman and colleagues (47), reductions in traffic-related air pollutants were associated with as much as a 91.4 mL increase in FEV_1. In comparison, an African American male of average age and height in our study would have an expected FEV_1 of 2806 mL. A gain of 3.58% in FEV_1 would translate to 100.5 mL. This increase in lung function on a population level can help reduce requirement of chronic and rescue medications, reduce asthma-related hospitalizations and oral corticosteroid use, and reduce the costs of asthma to patients, their families, and the general public.

Possible mechanisms for the protective effects of breastfeeding on lung function in general include: maternal immunity passed to the child inferring a protective effect on airway inflammation (48,49), preventing infections in early life (50), or through microbiome modulation (51,52). Because African Americans have lower lung volumes compared to non-Hispanic whites (53), it is possible that these effects may be more pronounced in this group. More studies are required to identify the mechanism or combination of mechanisms involved in the relationship between breastfeeding and increased lung function, and why this association seems to be greater among African American youths with asthma. Gene-environment interactions have been reported between asthma and breastfeeding (54,55). Given the variation in exposures and genetic background represented in our multi-ethnic study population, investigating potential modifying effects of genetic polymorphisms may be a reasonable next step. In fact, several polymorphisms reported to interact with breastfeeding and asthma (54) appear to occur at differing frequencies by race (56).

The results of our analyses should be interpreted with certain limitations. First, breastfeeding was recorded as a dichotomous variable in our questionnaire. It is possible that participants who were seldom breastfed or breastfed for a short time period responded differently to the question, “Was the child ever breastfed?” Because colostrum still has potential beneficial immunological effects (57), this may affect the measured lung function of each group. Further studies examining breastfeeding exclusivity and duration may provide insight on potential dose-response and time-dependent associations. Inclusion of sufficient ethnic subgroups would also allow for examination of heterogeneity of effects across ethnicity and extend the findings recently published based on a Finnish cohort (58). Despite this limitation and the potential for measurement error, we still identified breastfeeding as a positive influence on FEV_1 % predicted in African Americans. Furthermore, we preliminarily examined other markers of lung function, such as pre-bronchodilator forced vital capacity % predicted, post-bronchodilator FEV_1, and bronchodilator response, and found that breastfeeding was positively associated with these indicators (data not shown). Future

directions include studying these associations more closely, as they have major implications in respiratory medicine. A second limitation may be related to the prevalence of breastfeeding, which we found to be lower in our study population (76.2% for Mexican Americans, and 66.9% for mixed/other Latinos 66.9%) compared to nationally reported figures for Hispanics overall (80.0%) (12). However, the general pattern in the prevalence of breastfeeding in our study population resembles known patterns, with African Americans and Puerto Ricans having lower rates of breastfeeding compared to Mexican Americans and mixed/other Latinos (11). Thirdly, 46% of our participants were excluded from our analysis due to missing data (primarily because of missing data on family income genetic ancestry), which reduces the power of our analysis. However, the proportion of total eligible participants excluded in our study due to missing income data (12.9%) is less than the typical non-response rate of 25% (59). Also, despite the exclusion of participants due to missing data, we still found a positive association between breastfeeding and lung function in asthma in African Americans. Furthermore, the variables that were significantly different between complete and incomplete data were not associated with our outcomes in our final model. When these covariates (maternal prenatal smoking, chest illness before age of 2, gender, birth weight) were removed from our model and the study sample was expanded to include an additional 92 previously excluded participants, the magnitude of associations between breastfeeding and our primary and secondary outcomes did not change appreciably in any group (data not shown). We also examined multiple imputation methods to assess the potential influence of missing data. We found that imputation-based point estimates validated our initial results for change in FEV1% predicted (imputed estimate for African Americans = 3.00, p-value = 0.005) but not for exacerbations (prevalence ratio = 0.93, p-value = 0.36). Given that asthma medication use could affect baseline lung function and exacerbation-related outcomes, the generalizability of our findings may be limited to children with asthma who have characteristics similar to those included in our analysis.

Finally, while we adjusted for covariates such as family income, maternal education, health insurance status, and prenatal maternal smoking, it is possible that they may still have residual effects on our outcome despite controlling for them statistically. We considered other variables from our fully adjusted models for interaction effects but did not find evidence of effect modification. We also acknowledge that our selection of covariates does not necessarily provide all indicators of health awareness, access to care, or childhood development. A recent study examining asthma risk among siblings suggested that siblings discordant for breastfeeding had little difference in asthma incidence (10). While our study examined different outcomes (lung function among youths already with asthma and asthma exacerbations), and focused on populations that are frequently underrepresented in biomedical literature (13), it is important to acknowledge the complexity of accounting for one’s entire societal and environmental influence in childhood.

Conclusion

We report that breastfeeding is positively associated with FEV_1 % predicted and is negatively associated with asthma exacerbations in African Americans with asthma. Our findings emphasize the importance of breastfeeding in a population that is known to have

low rates of breastfeeding, as well as the need for larger studies to be done to replicate and discover the mechanism of this association in these populations.

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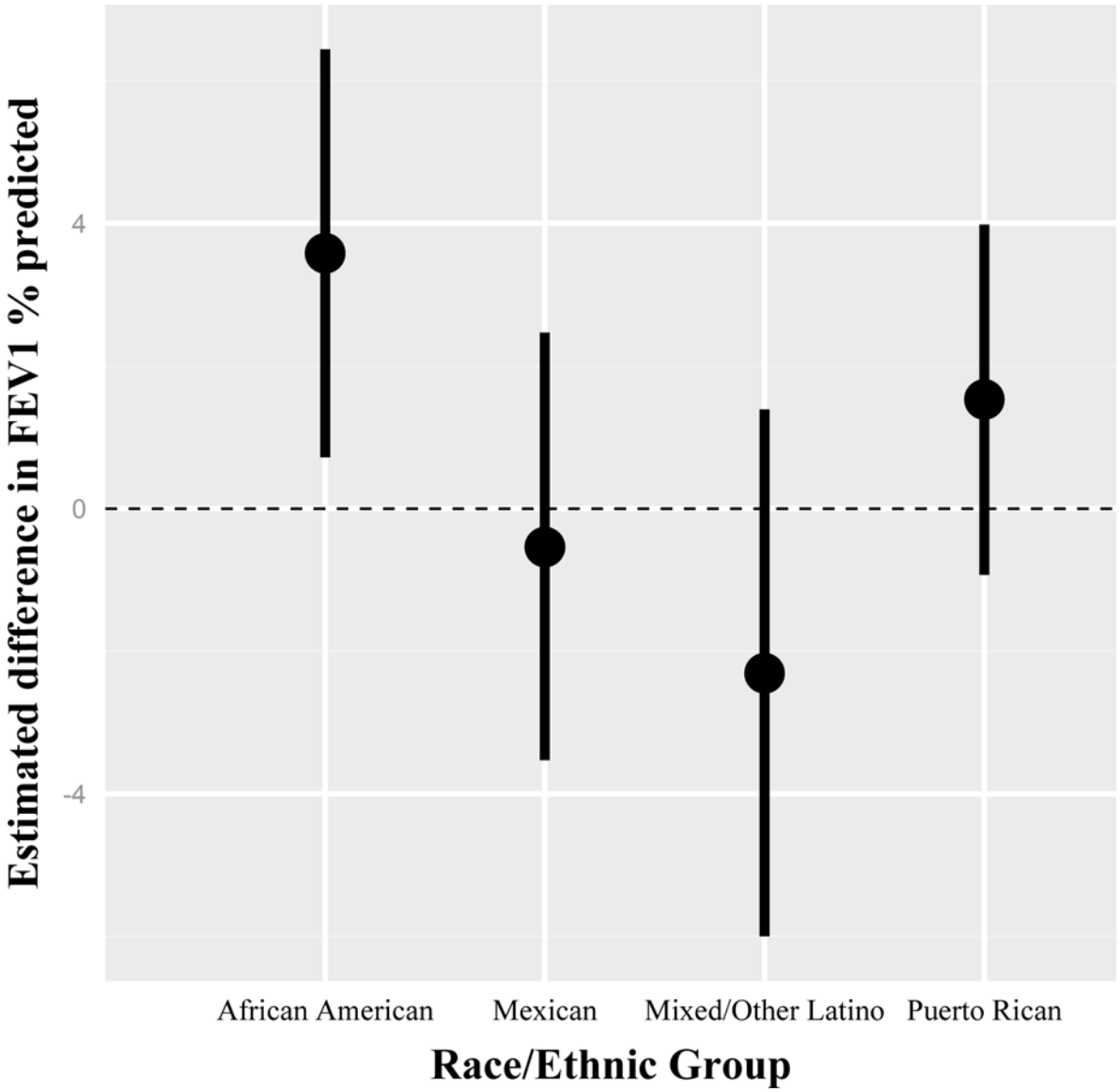

Figure 1. Association between breastfeeding and FEV_1 % predicted among youths with asthma in Study A and Study B: 2008–2014.

Estimates adjusted for proportion of Native American ancestry for Latinos, proportion of African ancestry for African Americans, body mass index category, socioeconomic status, total IgE levels, family history of asthma, chest illnesses before age of 2, maternal prenatal smoking, birth weight, recruitment center and sex.

Table 1.

Characteristics of subjects by race/ethnicity and breastfeeding status among children and adolescents enrolled in the GALA II & SAGE II studies: 2008–2014.*

Characteristic	African American (426)		Mexican American (424)		Mixed/Other Latino (255)		Puerto Rican (629)	
Breastfed	No 173 (40.6%)	Yes 253 (59.4%)	No 101 (23.8%)	Yes 323 (76.2%)	No 87 (33.1%)	Yes 168 (66.9%)	No 284 (45.1%)	Yes 345 (54.9%)
Age (years)	13.4 (10.7, 16.3)	13.1 (10.4, 15.6)	12.6 (10.1, 15.36)	12.3 (9.7, 14.3)	11.2 (9.4, 13.6)	12.0 (10.0, 14.2)	11.8 (10.1, 14.0)	11.3 (9.5, 13.7)
Male	**81 (46.8%)**	**151 (59.7%)**	55 (54.5%)	199 (62.0%)	57 (65.5%)	93 (55.4%)	163 (57.4%)	191 (55.4%)
Recruitment center								
-Bronx, NY	0 (0%)	0 (0%)	8 (7.9%)	13 (4.0%)	43 (49.4%)	48 (28.6%)	33 (11.6%)	17 (4.9%)
-Chicago, IL	0 (0%)	0 (0%)	35 (34.7%)	117 (36.2%)	11 (12.6%)	22 (13.1%)	22 (7.7%)	13 (3.8%)
-Houston, TX	0 (0%)	0 (0%)	37 (36.6%)	84 (26.0%)	12 (13.8%)	25 (14.9%)	0 (0%)	1 (0.3%)
-Puerto Rico	0 (0%)	0 (0%)	0 (0%)	0 (0%)	3 (3.4%)	4 (2.4%)	229 (80.6%)	314 (91.0%)
-SF Bay Area, CA	173 (100%)	253 (100%)	21 (20.8%)	109 (33.7%)	18 (20.7%)	69 (41.1%)	0 (0%)	0 (0%)
BMI category								
-Underweight	0 (0%)	0 (0%)	2 (2.0%)	4 (1.2%)	3 (3.5%)	4 (2.4%)	18 (6.3%)	27 (7.8%)
-Normal	71 (41.0%)	119 (47.0%)	41 (40.6%)	124 (38.3%)	25 (28.7%)	70 (41.7%)	133 (46.8%)	175 (50.7%)
-Overweight	37 (21.4%)	59 (23.3%)	17 (16.8%)	68 (21.1%)	17 (19.5%)	31 (18.4%)	47 (16.6%)	46 (13.3%)
-Obese	65 (37.6%)	75 (29.7%)	41 (40.6%)	127 (39.3%)	42 (48.3%)	63 (37.5%)	86 (30.3%)	97 (28.1%)
FH asthma	120 (69.4%)	155 (61.3%)	35 (34.7%)	95 (29.4%)	45 (51.7%)	84 (50.0%)	183 (64.4%)	226 (65.5%)
Prenatal smoking	**38 (22.0%)**	**30 (11.9%)**	4 (4.0%)	16 (5.0%)	3 (3.4%)	5 (3.0%)	25 (8.8%)	18 (5.2%)
SES score	**7.0 (6.0, 8.0)**	**8.0 (7.0, 9.0)**	6.0 (5.0, 7.0)	6.0 (5.0, 7.0)	**7.0 (6.0, 7.5)**	**6.0 (5.0, 7.0)**	**6.0 (6.0, 8.0)**	**7.0 (6.0, 8.0)**
Proportion of African ancestry	0.83 (0.78, 0.86)	0.80 (0.73, 0.86)	0.04 (0.02, 0.04)	0.04 (0.03, 0.05)	**0.16 (0.07, 0.28)**	**0.09 (0.04, 0.20)**	0.20 (0.15, 0.26)	0.18 (0.14, 0.28)
Birthweight (lbs)	**7.0 (6.1, 7.9)**	**7.4 (6.6, 8.2)**	7.0 (6.4, 7.9)	7.4 (6.6, 8.1)	**7.0 (6.0, 8.0)**	**7.4 (6.5, 8.3)**	6.9 (6.2, 7.5)	7.0 (6.3, 7.8)
Chest Illness before Age 2	102 (59.0%)	138 (54.5%)	44 (43.6%)	125 (38.7%)	50 (57.5%)	90 (53.6%)	199 (70.1%)	257 (74.5%)
Total IgE (kU/L)	208.5 (54.1, 479.5)	198.4 (56.2, 483.5)	158.6 (52.1, 462.0)	182.1 (48.9, 457.9)	171.4 (64.7, 518.9)	158.5 (51.1, 453.4)	272.7 (86.7, 696.2)	325.3 (117.2, 820.2)
Asthma-related hospitalizations in past year	11 (6.4%)	6 (2.4%)	8 (7.9%)	23 (5.4%)	7 (8.0%)	7 (4.2%)	28 (9.9%)	44 (12.8%)
Asthma-related ED visits in past	76 (43.9%)	78 (30.8%)	35 (34.6%)	88 (27.2%)	42 (48.3%)	73 (28.6%)	173 (60.9%)	238 (69.0%)

Characteristic	African American (426)		Mexican American (424)		Mixed/Other Latino (255)		Puerto Rican (629)	
year								
Oral steroid use in past year	40 (23.1%)	44 (17.4%)	21 (20.8%)	42 (13.0%)	32 (36.8%)	38 (14.9%)	134 (47.2%)	184 (53.3%)

*Non-categorical values expressed as median (interquartile range). Abbreviations: BF – breastfeeding. SES – composite measure of socioeconomic status based on income, education, and insurance status. FH – family history. Statistically significant differences between breastfed and non-breastfed participants within each racial or ethnic group (determined by Mann-Whitney U test or chi-square test with $p<0.05$) are in bold face type.

Table 2.

Change in percentage of predicted FEV1 achieved and 95% confidence intervals as indicated by regression coefficients from multivariable linear regression models among children and adolescents enrolled in Study A and Study B: 2008–2014.

Variable	African Americans	Mexicans	Mixed/Other Latinos	Puerto Ricans
Breastfeeding	**3.58 (0.72, 6.44)**	−0.54 (−3.53, 2.47)	−2.31 (−6.00, 1.39)	1.53 (−0.93, 3.98)
Male gender	−1.37 (−4.09, 1.34)	−2.19 (−4.82, 0.44)	0.65 (−2.90, 4.19)	0.51 (−1.88, 2.91)
SES score	−0.54 (−1.66, 0.58)	0.27 (−0.68, 1.21)	−0.21 (−1.46, 1.03)	0.07 (−0.84, 0.98)
FH asthma	−0.83 (−3.67, 2.02)	−0.44 (−3.20, 2.33)	−0.58 (−3.98, 2.83)	−2.19 (−4.67, 0.30)
Maternal Prenatal smoking	−2.94 (−6.73, 0.86)	4.69 (−1.24, 10.63)	−3.29 (−12.99, 6.41)	0.18 (−4.64, 4.99)
BMI category				
Underweight	N/A	**−13.60 (−24.32, −2.88)**	−7.41 (−17.97, 3.15)	**−7.52 (−12.29, −2.75)**
Overweight	3.36 (−0.11, 6.82)	1.77 (−1.70, 5.22)	3.55 (−1.18, 8.26)	0.63 (−2.90, 4.16)
Obese	2.12 (−0.99, 5.23)	**3.98 (1.11, 6.85)**	**5.53 (1.75, 9.31)**	1.44 (−1.37, 4.26)
Chest Illness before age 2	−0.22 (−2.92, 2.48)	−0.97 (−3.57, 1.63)	−0.92 (−4.48, 2.64)	**3.40 (0.72, 6.08)**
Birth weight	0.21 (−0.71, 1.13)	0.55 (−0.36, 1.46)	0.20 (−0.95, 1.35)	−0.09 (−1.00, 0.83)
African Ancestry	**−2.99 (−4.14, −1.85)**	−3.13 (−7.15, 0.90)	**−0.18 (−3.44, −0.17)**	**−1.75 (−2.84, −0.66)**
Native American Ancestry	N/A	0.61 (−0.34, 1.57)	−0.61 (−1.80, 0.58)	1.54 (−1.63, 4.71)
Center				
New York	N/A	**−10.89 (−17.45, −4.34)**	**−8.60 (−14.92, −2.28)**	−4.85 (−11.41, 1.72)
Texas	N/A	2.88 (−0.36, 6.12)	−2.31 (−8.80, 4.18)	−0.08 (−30.12, 29.94)
Puerto Rico	N/A	N/A	−11.49 (−23.04, 0.36)	−1.78 (−7.11, 3.54)
San Francisco	N/A	**4.81 (1.68, 7.95)**	−0.05 (−5.65, 5.54)	N/A

Breastfeeding in infancy increases percentage of predicted FEV1 achieved in African Americans (p-value 0.015). Reference level for BMI category is normal BMI. Reference level for recruitment center is Chicago. Statistically significant differences bolded.

Table 3.

Crude and adjusted prevalence ratios for association between breastfeeding and asthma exacerbations in youths with asthma in the GALA II and SAGE II studies: 2008–2014.

	Crude PR (95% CI)	Adjusted PR (95% CI)
African Americans	0.72 (0.61 – 0.86)	0.79 (0.64 – 0.98)
Mexicans	0.84 (0.67 – 1.06)	0.90 (0.68 – 1.18)
Mixed/Other Latinos	0.92 (0.76 – 1.12)	0.94 (0.72 – 1.23)
Puerto Ricans	1.10 (0.99 – 1.24)	1.07 (0.95 – 1.21)

Prevalence ratios adjusted for proportion of Native American ancestry for Latinos, proportion of African ancestry for African Americans, body mass index category, socioeconomic status, total IgE levels, family history of asthma, pulmonary illnesses before age of 2, maternal prenatal smoking, birth weight, recruitment center, and sex.