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Racial/Ethnic differences in eligibility for asthma biologics among pediatric populations

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Abstract

Background—Asthma is a heterogeneous disease. Clinical blood parameters differ by race/ethnicity and are used to distinguish asthma subtypes and inform therapies. Differences in subtypes may explain population-specific trends in asthma outcomes. However, these differences in racial/ethnic minority pediatric populations are unclear.

Objective—Investigate the association of blood parameters and asthma subtypes with asthma outcomes and examine population-specific eligibility for biologic therapies in minority pediatric populations.

Methods—Using data from two asthma case-control studies of pediatric minority populations, we performed case-control (N=3,738) and case only (N=2,743) logistic regressions to quantify the association of blood parameters and asthma subtypes with asthma outcomes. Heterogeneity of these associations was tested using an interaction term between race/ethnicity and each exposure. Differences in therapeutic eligibility were investigated using chi-square tests.

Results—Race/ethnicity modified the association between total immunoglobulin E (IgE) and asthma exacerbations. Elevated IgE was associated with worse asthma outcomes in Puerto Ricans. Allergic asthma was associated with worse outcomes in Mexican Americans whereas eosinophilic asthma was associated with worse outcomes in Puerto Ricans. A lower proportion of Puerto Ricans met dosing criteria for allergic asthma-directed biologic therapy than other groups. A higher proportion of Puerto Ricans qualified for eosinophilic asthma-directed biologic therapy than African Americans.

Conclusion—We found population-specific associations between blood parameters and asthma subtypes with asthma outcomes. Our findings suggest that eligibility for asthma biologic therapies differs across pediatric racial/ethnic populations. These findings call for more studies in diverse populations for equitable treatment of minority patients with asthma.

Capsule Summary:

Blood parameters differ between African American, Mexican American, and Puerto Rican children. More Puerto Rican children may benefit from eosinophil-directed biologic therapies, but fewer met criteria for anti-IgE therapy than other groups.

Keywords

Asthma; Pediatric asthma; Biomarker-driven asthma therapeutics; Asthma subtypes; Peripheral blood parameters; White blood cell count; Total immunoglobulin E; Minority pediatric populations

Introduction

Asthma is a chronic inflammatory obstructive lung disease associated with significant morbidity and mortality for racial/ethnic minority groups.[1] Asthma is the most common and racially/ethnically disparate chronic respiratory disease in children.[2] Lifetime asthma prevalence is greater among Puerto Rican (23.6%) and African American children (18.1%) than among Mexican American (11.5%), and White (9.5%) children.[3] Asthma mortality is 4-fold higher in Puerto Ricans and African Americans than in Mexican Americans.[4] Populations with the highest asthma prevalence and mortality also tend to be the least responsive to commonly prescribed asthma therapies.[5–9] While the etiology of asthma is complex, resulting from the confluence of genetic, environmental, and socio-cultural risk factors the causal basis for these racial/ethnic health disparities remains elusive.

Asthma is a heterogeneous disease composed of multiple, sometimes overlapping, pathobiological and clinical subtypes.[10] Delineating these clinical subtypes is a challenge for clinicians, who must choose between different biologic therapies for their patients. Currently approved asthma biologics in the United States (U.S.) primarily target allergic or eosinophilic asthma. Blood parameters are used to determine eligibility and dosing regimens of these biologics, yet evidence shows that clinical blood profiles differ by race/ethnicity.[11, 12] The lack of population-based information on asthma therapeutic-associated blood parameters in racially/ethnically diverse pediatric populations can leave clinicians uncertain about the choice of biologic therapy for their patients. This is especially true for non-White patients, who have been left out of pulmonary and asthma-related clinical and biomedical research.[13] Having accurate, population-based information for racial/ethnic minority children is of critical concern given that minorities comprise 50% of children in the U.S.[14] Other asthma subtypes such as neutrophilic, late-onset, and obesity-related asthma[10] do not have subtype-directed asthma therapies at this time. Thus, the study of asthma blood profiles may provide insight into population-specific asthma biology and help inform therapeutic management.

We hypothesized that clinical blood profiles and asthma subtypes are differentially associated with asthma outcomes across racial/ethnic populations. We also hypothesized that eligibility for asthma biologic therapies differs across populations. To address these hypotheses, we examined the association of blood parameters and clinical subtypes with asthma outcomes using case-control and case-only analyses in two richly phenotyped pediatric African American and Latino cohorts with and without asthma. In addition, we assessed population-specific eligibility for blood biomarker-informed biologic therapies in those with moderate-to-severe asthma.

Methods

Recruitment of Parent Study Population

The Genes-environments & Admixture in Latino Americans study (GALA II) and the Study of African Americans, Asthma, Genes, & Environments (SAGE) are parallel case-control studies using similar protocols and questionnaires, previously described.[15] Briefly, GALA II recruited Hispanics/Latinos from five urban study centers across the mainland U.S. (Chicago, IL; Bronx, NY; Houston, TX; San Francisco Bay Area, CA) and Puerto Rico between 2006 and 2014 using a combination of community and clinic-based recruitment. SAGE recruited African Americans from the San Francisco Bay Area only. In both studies, participants were 8 to 21 years old at recruitment. Cases had physician-diagnosed asthma and asthma symptoms and/or asthma medication use within the last two years, with no history of other lung or chronic non-allergic illnesses. Healthy controls had no history of asthma or allergies, use of allergy medications, or symptoms of wheezing or shortness of breath during their lifetime. Control subjects were 1:1 frequency matched within each recruitment center by age (within 1 year). Case subjects and control subjects were recruited from similar geographic regions. Those in the third trimester of pregnancy, current smokers, and those with at least a 10 pack-year smoking history were ineligible. Parents and grandparents of study participants must have self-identified as Hispanic/Latino or African American. At the time of recruitment detailed clinical measures and biological specimens were collected, along with questionnaire-based information regarding additional social, environmental, and historical risk factors. The study protocols for both GALA II and SAGE were approved by the University of California San Francisco (UCSF) Human Research Protection Program Institutional Review Board (IRB). Detailed consenting procedures can be found in the Online Repository.

Asthma Outcomes

Asthma outcomes were defined as follows: asthma status (yes/no), asthma severity (moderate-to-severe/mild), asthma control (uncontrolled/controlled), and at least one asthma exacerbation in the year prior to recruitment (yes/no). Detailed definitions of asthma outcomes are provided in the Online Repository.

Measurement of Blood Parameters

Serum total immunoglobulin E (IgE) was measured in our research lab from plasma in duplicate on a Phadia 100 detection system (ThermoFisher Scientific, Uppsala, Sweden). If both measurements were not within 10% concordance, a 3rd measurement was assayed. White blood cell (WBC) counts were obtained from complete blood counts with differentials using commercially available and Clinical Laboratory Improvement Amendments (CLIA)-certified laboratories through Quest Diagnostics in the GALA II dataset and through UCSF Clinical Laboratories for SAGE. Serum total IgE and WBC counts were specified as continuous predictors. However, the distributions of serum total IgE, basophils, and eosinophils were highly right-skewed and were log-transformed for analysis purposes.

Defining Asthma Subtypes

Allergic asthma was defined as having asthma and any sensitization to aeroallergens by skin prick test.[16] Details on assessment of skin prick positivity can be found in the Online Repository. Eosinophilic asthma was defined as having asthma and an absolute eosinophil count (AEC) ≥150 c/uL (≥300 c/uL separately assessed in the Online Repository).[17] These asthma subtypes were specified as yes or no. Overlap between subtypes was only assessed in African Americans as they were the only population in our study with an overlap between skin prick and WBC data.

Defining Eligibility for Blood Biomarker-Informed Asthma Biologic Therapies

For allergic asthma therapy, dosing of anti-IgE therapy is based on pre-treatment serum total IgE level. The U.S. Food and Drug Administration (FDA)-approved dosing range for this therapy requires the level of pretreatment serum total IgE to be >30 kU/L and either <1,300 kU/L for children 6–11 years old or <700 kU/L for those 12 years or older.[18–22] For this eligibility analysis, allergic asthma was defined as having asthma and sensitization to at least one perennial aeroallergen (dust mite, dog, cat, cockroach, mouse and rat) by skin prick test. Participants with moderate-to-severe, allergic asthma were considered eligible for anti-IgE therapy if they fell within their age-specific limits and ineligible otherwise. For eosinophilic asthma therapy, eligibility was assessed using a common clinical threshold for therapeutic use: AEC 150 c/uL.[17, 23–26] The age indication for most eosinophil directed therapies is 12 years old.[27–29] Therefore, participants must have been at least 12 years of age, and were considered eligible if their AEC was equal to or above the threshold and ineligible otherwise.

Covariates

Covariates considered for this analysis were age, sex, obesity status, socioeconomic status (SES), and inhaled corticosteroid (ICS) use within 2 weeks of recruitment. Detailed descriptions are provided in the Online Repository.

Study Inclusion and Exclusion Criteria

Of the 5,147 GALA II participants, those who identified themselves as Hispanic/Latino subgroups other than Mexican American or Puerto Rican or whose grandparents were not identified as the same race/ethnicity were excluded (N=957). Of the 1,710 total SAGE participants, participants whose four grandparents did not all identify as African American were excluded (N=126). After combining both GALA II and SAGE participants, those missing both total IgE data and WBC count data (N=831), those who used oral steroids within 2 weeks of recruitment (N=40), and those missing obesity status (N=1,165) were also excluded for an analytical sample of 3,738 cases and controls. Analyses for asthma outcomes (severity, control, and exacerbations) included cases only (N=2,743). Analyses investigating the proportion of each population that were eligible for various biologic therapies were restricted to participants with moderate-to-severe asthma (N=1,917). A consort diagram is visualized in Figure E1. Additional details on analysis-specific inclusions and sample sizes are outlined in Table E1.

Statistical Analysis

Descriptive statistics were calculated for both demographic and clinical characteristics for the total population and according to race/ethnicity. We used logistic regressions to test an interaction term of race/ethnicity with each exposure to examine the heterogeneity of their association with asthma outcomes in the total population. We then quantified these associations via odds ratios (OR) and confidence intervals (CI) in each racial/ethnic group (African American, Mexican American and Puerto Rican) adjusting for age, sex, obesity status, SES, and ICS use. Mexican American participants were excluded from WBC count analyses due to small sample size (N=33). Due to the bimodal distribution of basophils in Puerto Ricans (Figure E2), the association of basophils with asthma and asthma outcomes was analyzed only in African Americans. In addition, we examined the proportion of participants from each racial/ethnic group with moderate-to-severe asthma that would be ineligible for anti-IgE and eosinophilic asthma-directed therapies. We used chi-squared tests of independence to examine whether the proportion of those ineligible differed between populations.

All statistical analyses were performed with R v.3.6.2.

Results

Demographic Characteristics

Baseline study population characteristics for the total population and stratified by race/ethnicity are presented in Table 1. In our population (N=3,738), 1,275 self-identified as African American, 967 as Mexican American, and 1,496 as Puerto Rican. Almost half of the study population were female (49.0%) and almost a third were classified as obese (31.9%). Mexican Americans were more likely to be obese compared to other racial/ethnic groups ($p<0.001$). In our study population, 2,743 (73.4%) participants had asthma. Mexican Americans had the lowest proportion of poor asthma outcomes ($p<0.05$). A higher proportion of Puerto Ricans had eosinophilic asthma compared to African Americans ($p<0.01$), and proportions of those with allergic asthma differed significantly between racial/ethnic groups ($p<0.05$; Table E2).

Distribution of Blood Parameters

Total IgE levels were significantly higher in Puerto Ricans compared to African Americans and Mexican Americans ($p<0.001$). Basophil, eosinophil, monocyte, and neutrophil counts differed significantly between African Americans and Puerto Ricans ($p<0.001$), as shown in Figure E2.

Effect of Blood Parameters on Asthma Outcomes

We observed a significant interaction of race/ethnicity with IgE levels for asthma exacerbations between African Americans and Puerto Ricans ($p=0.04$) as shown in Figure 1. After adjustment for age, sex, obesity status, SES, and ICS use, higher IgE levels were significantly associated with greater odds of asthma in all three racial/ethnic groups: African American (OR=1.33; CI=1.21–1.45), Mexican American (OR=1.35, CI=1.22–1.50), and Puerto Rican (OR=1.27; CI=1.16–1.40). In addition, higher IgE levels were

significantly associated with worse asthma severity in African Americans (OR=1.11; CI=1.00–1.23) and Puerto Ricans (OR=1.17; CI=1.06–1.29), worse asthma control in African Americans (OR=1.11; CI=1.00–1.23) and Puerto Ricans (OR=1.13; CI=1.03–1.25), and more exacerbations in Puerto Ricans (OR=1.23; CI=1.13–1.34). Puerto Ricans were the only group with significant associations between increased IgE and worsening of all asthma outcomes.

Higher eosinophil count was significantly associated with greater odds of asthma in African Americans and Puerto Ricans (OR=1.55; CI=1.10–2.23 and OR=1.66; CI=1.23–2.24, respectively), but associated with exacerbations (OR=1.67; CI=1.18–2.38) in Puerto Ricans only. Higher lymphocyte counts were significantly associated with greater odds of asthma in African Americans only (OR=1.05; CI=1.00–1.10) while higher monocyte counts were significantly associated with lower odds of asthma in Puerto Ricans only (OR=0.84; CI=0.74–0.96). Neutrophils were not associated with asthma or asthma outcomes in African Americans or Puerto Ricans. All ORs and CIs for this analysis are provided in Table E3.

Effect of Asthma Subtypes on Asthma Outcomes

We observed some associations between asthma subtypes and asthma outcomes in Puerto Ricans and Mexican Americans but not in African Americans (Figure 2). After controlling for age, sex, obesity status, SES, and ICS use, eosinophilic asthma was associated with worse asthma severity (OR=1.96; CI=1.15–3.37), worse asthma control (OR=1.74; CI=1.01–3.00) and exacerbations (OR=1.81; CI=1.10–2.98) in Puerto Ricans only. Allergic asthma was associated with worse asthma control (OR=1.49; CI=1.02–2.19), and exacerbations (OR=1.82; CI=1.19–2.83) only in Mexican Americans. Heterogeneity was not observed for the associations between asthma subtypes and asthma-related outcomes by race/ethnicity ($p>0.05$). All ORs and CIs for this analysis are provided in Table E4. Overlap of allergic and eosinophilic asthma in 122 African Americans is presented in Table E5.

Eligibility for Allergic and Eosinophilic Asthma Biologics Across Populations

In our study, Puerto Ricans were significantly less likely to be eligible for anti-IgE therapy than other groups, but significantly more likely to qualify for eosinophilic asthma-directed therapies. Specifically, 17.2% of African Americans, 21.2% of Mexican Americans, and 31.4% of Puerto Ricans with moderate-to-severe, allergic asthma had pre-treatment IgE either too low to qualify (<30 kU/L) or too high to recommend a dose for anti-IgE therapy (>700 kU/L for ages 12+, >1,300 kU/L for ages 6–11; Figure 3A).[20] Proportion plots for each pre-treatment IgE threshold can be found in Figure E3. We found that 51.3% of African Americans and 26.8% of Puerto Ricans age 12 and older with moderate-to-severe asthma had AEC <150 c/uL (Figure 3B) and would not qualify for eosinophilic asthma-directed therapies. A proportion plot for an AEC <300 c/uL cutoff can be found in Figure E4. We additionally examined these proportions for those age 6 and older, as is indicated for the eosinophilic asthma-directed therapy duplimab,[29] and found that the proportions were nearly identical. Significant differences in population eligibility for anti-IgE therapy and eosinophilic asthma-directed therapy age 12 and older are presented in Table E6.

Discussion

Clinical blood profiles affect asthma outcomes and determine many clinical and therapeutic options. These profiles also differ by race/ethnicity.[11, 12] We found that increased levels of serum total IgE were highly associated with asthma status across African American, Mexican American, and Puerto Rican children. Serum total IgE is a biomarker and biologic therapeutic target associated with allergic asthma and with decreased lung function in patients with asthma.[30] Previous research in children has associated IgE with asthma severity.[31, 32] Within our Puerto Rican population, increased IgE levels were significantly associated with severe asthma, worse asthma control, and a history of asthma exacerbations. We did not observe the same pattern among African Americans, where increased IgE was only associated with severe asthma and poor asthma control, or Mexican Americans, where increased IgE was not associated with any of these outcomes.

Our findings of racial/ethnic-specific blood profiles and associations with asthma outcomes may suggest different asthma pathobiology or environmental effects in the populations studied. It has been previously shown that peripheral blood eosinophil counts are associated with eosinophilic asthma, as measured by airway eosinophils and asthma outcomes.[33, 34] While eosinophil count was significantly associated with asthma in both African American and Puerto Rican groups, only in our Puerto Rican population was higher eosinophil count associated with a history of asthma exacerbations. It is possible that Puerto Ricans and African Americans may have a different pathobiological basis for poor asthma outcomes, and that Puerto Ricans may benefit more from eosinophil-directed biologic therapies than other racial/ethnic groups. We note that baseline AEC was elevated in Puerto Ricans relative to African Americans regardless of asthma status. It has been reported that elevated baseline AEC is a predictor of treatment response to mepolizumab therapy for asthma.[35] Whether or not elevated baseline AEC predisposes the Puerto Rican population to eosinophilic disease is yet unknown.

The associations between clinically significant predictors and disease outcomes produced surprising results. Specifically, Mexican Americans were the only population studied with any significant associations between allergic asthma and worse asthma outcomes. Additionally, eosinophilic asthma was significantly associated with worse asthma severity, control, and exacerbations in Puerto Ricans only, which suggests that eosinophil-directed biologic therapies may benefit Puerto Ricans more than other populations. While these findings may be due to population-specific differences in social and environmental exposures or genetic ancestry proportions, further studies are needed to fully understand the effect that race/ethnicity has on allergic asthma outcomes.

Our study of children with moderate-to-severe asthma from different racial/ethnic groups provide novel insights on the therapeutic options available for these three populations of children. Overall, we found that a smaller proportion of Puerto Ricans would meet FDA-approved thresholds for anti-IgE dosing using pre-treatment IgE thresholds of <700 kU/L or <1,300 kU/L, compared with African Americans or Mexican Americans. In contrast, for eosinophilic asthma, a smaller proportion of African Americans qualified for eosinophilic asthma-directed therapies based on pre-treatment AEC ≥150, when compared with Puerto

Ricans. These differences highlight the need for future study of asthma biologic therapies in racially/ethnically diverse populations, which may identify clinical subgroups that would benefit most from targeted biologic therapies.

The underlying basis for the differences in peripheral blood parameters and racial/ethnic groups is likely multifactorial.[11] WBC counts are known to be affected by genetic ancestry, with African ancestry being associated with lower neutrophil counts and some elevations in eosinophil and other WBC counts, due to variation at the Duffy locus..[36,37] Herein, Puerto Ricans had a higher average absolute neutrophil counts and elevated eosinophil counts relative to African Americans. On average, Puerto Ricans have lower proportions of African ancestry than African Americans.[38] Relative to Mexican Americans and other Latino populations, the Puerto Rican population has more African admixture and a lower proportion of Native American ancestry.[39] More broadly, the expressed blood parameters of various global populations may be influenced by their particular genetic background; related to history, geography, and other factors. An expanding list of genetic variants is known to play a role in WBC count differentials, which varies by race/ethnicity across studies.[37,40,41] While environmental conditions[42] may affect eosinophil counts, and could relate to the observed differences between Puerto Ricans and African Americans, participants were enrolled in urban settings for both GALA II and SAGE studies, respectively. Although parasitic infections can increase absolute eosinophil count, these infections are now rare in Puerto Rico, consistent with the island's high human development index and Center for Disease Control and Prevention (CDC) traveler guidelines on the safety of drinking water[43, 44] in urban areas, where all patients were enrolled. None of the populations in our study had testing for parasitic infections, and we cannot evaluate whether this could have affected AEC values. Environmental and hereditary factors have been previously associated with serum total IgE levels.[45, 46] There are likely yet unknown genetic and environmental factors affecting the peripheral blood counts and IgE levels we observed, which may be clarified by future studies in racially/ethnically diverse populations.

One limitation of our study was that none of the participants were on biologic therapy for asthma, limiting our ability to make conclusions about blood profiles and associations with biologic therapeutic response. In this study, few participants had both skin prick and WBC data, which prevented us from assessing how overlapping subtypes affects asthma. In the real-world, asthma subgroups are not mutually exclusive; patients can have both allergic and eosinophilic asthma. Further research is needed to examine if having one or multiple subtypes influence an individual's risk for poor asthma outcomes or eligibility for asthma biologics. Furthermore, due to small samples sizes in some analyses as the result of unmeasured WBC count data, we cannot make definitive conclusions about racial/ethnic group-level differences in WBC counts and eligibility for eosinophilic-asthma directed therapy. We were also not able to determine which of the 40 patients taking OCS in the prior two weeks had been on chronic versus acute OCS therapy, and thus, could not assess the small proportion of patients who could qualify for dupilumab for OCS-dependent asthma. While research has suggested that differences in gut microbiomes may affect asthma outcomes, we were not able to assess the impact of microbiome differences in this study. Our study was also limited by the fact that we did not have a White population for comparison purposes. In addition, the blood profiles in our populations were measured

from a single point in time, which meant we could not analyze how longitudinal changes in blood profiles may impact disease outcomes or eligibility for biologics. However, our WBC data is reliable, given that these measurements were obtained from CLIA-certified labs. Additionally, there remains a lack of research in minority populations with asthma or lung disease.[13] This precluded us from being able to replicate our findings in an independent dataset for these three minority populations. Regardless, our analyses included the largest gene-environment study of asthma in minority children to date.

Overall, our findings suggest that peripheral blood parameters are associated with asthma outcomes in African American, Mexican American, and Puerto Rican children. In the U.S., available asthma biologic therapies target eosinophilic or allergic asthma. We found a greater proportion of Puerto Rican participants had eosinophilic asthma compared to African Americans. Unlike Puerto Ricans, African Americans did not have associations between increased eosinophil counts and poor asthma outcomes including more severe asthma or asthma exacerbations. Further research is needed to determine if these observed differences relate to differential treatment responses between racial/ethnic groups. Mexican Americans had the highest frequency of allergic asthma, which was uniquely associated with worse asthma control and exacerbations. Of participants with moderate-to-severe asthma, a higher proportion of African American and Mexican American participants than Puerto Rican participants met dosing criteria for treatment with anti-IgE therapy for allergic asthma, while a higher proportion of Puerto Rican than African American participants met criteria for eosinophilic asthma therapies. Selecting the correct biologic asthma therapy for a given patient remains a struggle for clinicians, which may be compounded in racial/ethnic minorities given the lack of clinical and biomedical research in these populations. While biologic therapies represent a new dawn in asthma care, that dawn has not yet risen for all patients of different racial/ethnic backgrounds. It is critical that current and future biomarker-driven asthma therapeutics are studied in patients of diverse backgrounds to bring maximal benefits to all patients.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations/Acronyms:

AEC	absolute eosinophil count
CDC	Center for Disease Control and Prevention
CI	confidence interval
CLIA	Clinical Laboratory Improvement Amendments
FDA	U.S. Food and Drug Administration
GALA II	the Genes-environments & Admixture in Latino Americans study
ICS	inhaled corticosteroids
IgE	immunoglobulin E
IRB	institutional review board
OR	odds ratios
SAGE	the Study of African Americans, Asthma, Genes, & Environments
SES	socioeconomic status
UCSF	University of California, San Francisco
WBC	white blood cell count

References:

1. Institute of Medicine (US) Committee on the Assessment of Asthma and Indoor Air. 3, Patterns Of Asthma Morbidity And Mortality. In: Clearing the Air: Asthma and Indoor Air Exposures. Washington (DC): National Academies Press (US); 2000.
2. Ferrante G, La Grutta S. The Burden of Pediatric Asthma. Front Pediatr 2018; 6:186. [PubMed: 29988370]
3. Table 2–1 Lifetime Asthma Prevalence Percents by Age, United States: National Health Interview Survey, 2018. 2019.] Available from https://www.cdc.gov/asthma/nhis/2018/table2-1.htm.
4. Akinbami LJ, Moorman JE, Bailey C, Zahran HS, King M, Johnson CA, et al. Trends in asthma prevalence, health care use, and mortality in the United States, 2001–2010. NCHS Data Brief 2012:1–8.
5. Burchard EG, Avila PC, Nazario S, Casal J, Torres A, Rodriguez-Santana JR, et al. Lower bronchodilator responsiveness in Puerto Rican than in Mexican subjects with asthma. Am J Respir Crit Care Med 2004; 169:386–92. [PubMed: 14617512]
6. Dixon AE. Long-acting beta-agonists and asthma: the saga continues. Am J Respir Crit Care Med 2011; 184:1220–1. [PubMed: 22162879]

7. Naqvi M, Thyne S, Choudhry S, Tsai HJ, Navarro D, Castro RA, et al. Ethnic-specific differences in bronchodilator responsiveness among African Americans, Puerto Ricans, and Mexicans with asthma. J Asthma 2007; 44:639–48. [PubMed: 17943575]
8. Nelson HS, Weiss ST, Bleecker ER, Yancey SW, Dorinsky PM, Group SS. The Salmeterol Multicenter Asthma Research Trial: a comparison of usual pharmacotherapy for asthma or usual pharmacotherapy plus salmeterol. Chest 2006; 129:15–26. [PubMed: 16424409]
9. Wechsler ME, Castro M, Lehman E, Chinchilli VM, Sutherland ER, Denlinger L, et al. Impact of race on asthma treatment failures in the asthma clinical research network. Am J Respir Crit Care Med 2011; 184:1247–53. [PubMed: 21885625]
10. Kuruvilla ME, Lee FE, Lee GB. Understanding Asthma Phenotypes, Endotypes, and Mechanisms of Disease. Clin Rev Allergy Immunol 2019; 56:219–33. [PubMed: 30206782]
11. Rappoport N, Paik H, Oskotsky B, Tor R, Ziv E, Zaitlen N, et al. Comparing Ethnicity-Specific Reference Intervals for Clinical Laboratory Tests from EHR Data. J Appl Lab Med 2018; 3:366–77. [PubMed: 33636914]
12. Finan C, Gaulton A, Kruger FA, Lumbers RT, Shah T, Engmann J, et al. The druggable genome and support for target identification and validation in drug development. Sci Transl Med 2017; 9.
13. Burchard EG, Oh SS, Foreman MG, Celedon JC. Moving toward true inclusion of racial/ethnic minorities in federally funded studies. A key step for achieving respiratory health equality in the United States. Am J Respir Crit Care Med 2015; 191:514–21. [PubMed: 25584658]
14. The Annie E. Casey Foundation. Child population by race in the United States. Kids Count Data Center.] Available from https://datacenter.kidscount.org/data/tables/103-child-population-by-race#detailed/1/any/false/1729,37,871,870,573,869,36,868,867,133/68,69,67,12,70,66,71,72/423,424.
15. Nishimura KK, Galanter JM, Roth LA, Oh SS, Thakur N, Nguyen EA, et al. Early-life air pollution and asthma risk in minority children. The GALA II and SAGE II studies. Am J Respir Crit Care Med 2013; 188:309–18. [PubMed: 23750510]
16. Tschopp JM, Sistek D, Schindler C, Leuenberger P, Perruchoud AP, Wüthrich B, et al. Current allergic asthma and rhinitis: diagnostic efficiency of three commonly used atopic markers (IgE, skin prick tests, and Phadiatop). Results from 8329 randomized adults from the SAPALDIA Study. Swiss Study on Air Pollution and Lung Diseases in Adults. Allergy 1998; 53:608–13. [PubMed: 9689343]
17. Kostikas K, Brindicci C, Patalano F. Blood Eosinophils as Biomarkers to Drive Treatment Choices in Asthma and COPD. Curr Drug Targets 2018; 19:1882–96. [PubMed: 29437007]
18. XOLAIR [prescribing information]. Genentech USA, Inc. and Novartis Pharmaceuticals Corporation; 2020.] Available from https://www.gene.com/download/pdf/xolair_prescribing.pdf.
19. Buhl R Anti-IgE: lessons from clinical trials in patients with severe allergic asthma symptomatic despite optimised therapy. European Respiratory Review 2007; 16:73–7.
20. Busse WW, Morgan WJ, Gergen PJ, Mitchell HE, Gern JE, Liu AH, et al. Randomized trial of omalizumab (anti-IgE) for asthma in inner-city children. N Engl J Med 2011; 364:1005–15. [PubMed: 21410369]
21. Chapman KR, Cartier A, Hébert J, McIvor RA, Schellenberg RR. The role of omalizumab in the treatment of severe allergic asthma. Can Respir J 2006; 13 Suppl B:1b–9b.
22. Kawakami T, Blank U. From IgE to Omalizumab. J Immunol 2016; 197:4187–92. [PubMed: 27864548]
23. Cardet JC, Israel E. Update on reslizumab for eosinophilic asthma. Expert Opin Biol Ther 2015; 15:1531–9. [PubMed: 26372797]
24. Emma R, Morjaria JB, Fuochi V, Polosa R, Caruso M. Mepolizumab in the management of severe eosinophilic asthma in adults: current evidence and practical experience. Ther Adv Respir Dis 2018; 12:1753466618808490.
25. FitzGerald JM, Bleecker ER, Nair P, Korn S, Ohta K, Lommatzsch M, et al. Benralizumab, an anti-interleukin-5 receptor α monoclonal antibody, as add-on treatment for patients with severe, uncontrolled, eosinophilic asthma (CALIMA): a randomised, double-blind, placebo-controlled phase 3 trial. Lancet 2016; 388:2128–41. [PubMed: 27609406]

26. Wenzel S, Ford L, Pearlman D, Spector S, Sher L, Skobieranda F, et al. Dupliumab in persistent asthma with elevated eosinophil levels. N Engl J Med 2013; 368:2455–66. [PubMed: 23688323]
27. Patient Information DUPIXENT (Du-pix-ent) (dupllimab) injection, for subcutaneous use. 2021.] Available from https://www.regeneron.com/sites/default/files/Dupixent_PPI.pdf.
28. NUCALA (mepolizumab) for injection. 2020.] Available from https://gskpro.com/content/dam/global/hcpportal/en_US/Prescribing_Information/Nucala/pdf/NUCALA-PI-PIL-IFU-COMBINED.PDF#nameddest=PIL.
29. Patient Information FASENRA (fas-en-rah) (benralizumab) injection, for subcutaneous use.] Available from https://den8dhaj6zs0e.cloudfront.net/50fd68b9-106b-4550-b5d0-12b045f8b184/3647bed4-ce91-4fe7-9bc5-32dbee73f80a/3647bed4-ce91-4fe7-9bc5-32dbee73f80a_pi_med_guide_rendition__c.pdf.
30. Ahmad Al Obaidi AH, Mohamed Al Samarai AG, Yahya Al Samarai AK, Al Janabi JM. The predictive value of IgE as biomarker in asthma. J Asthma 2008; 45:654–63. [PubMed: 18951256]
31. Borish L, Chipps B, Deniz Y, Gujrathi S, Zheng B, Dolan CM. Total serum IgE levels in a large cohort of patients with severe or difficult-to-treat asthma. Ann Allergy Asthma Immunol 2005; 95:247–53. [PubMed: 16200815]
32. Davila I, Valero A, Entrenas LM, Valveny N, Herráez L. Relationship between serum total IgE and disease severity in patients with allergic asthma in Spain. J Investig Allergol Clin Immunol 2015; 25:120–7.
33. Casciano J, Krishnan JA, Small MB, Buck PO, Gopalan G, Li C, et al. Value of peripheral blood eosinophil markers to predict severity of asthma. BMC Pulm Med 2016; 16:109. [PubMed: 27473851]
34. Zhang XY, Simpson JL, Powell H, Yang IA, Upham JW, Reynolds PN, et al. Full blood count parameters for the detection of asthma inflammatory phenotypes. Clin Exp Allergy 2014; 44:1137–45. [PubMed: 24849076]
35. Katz LE, Gleich GJ, Hartley BF, Yancey SW, Ortega HG. Blood eosinophil count is a useful biomarker to identify patients with severe eosinophilic asthma. Ann Am Thorac Soc. 2014 May;11(4):531–6. [PubMed: 24606022]
36. Reich D, Nalls MA, Kao WH, Akylbekova EL, Tandon A, Patterson N, et al. Reduced neutrophil count in people of African descent is due to a regulatory variant in the Duffy antigen receptor for chemokines gene. PLoS Genet 2009; 5:e1000360. [PubMed: 19180233]
37. Crosslin DR, McDavid A, Weston N, Nelson SC, Zheng X, Hart E, et al. Genetic variants associated with the white blood cell count in 13,923 subjects in the eMERGE Network. Hum Genet. 2012 Apr;131(4):639–52. [PubMed: 22037903]
38. Bryc K, Durand EY, Macpherson JM, Reich D, Mountain JL. The genetic ancestry of African Americans, Latinos, and European Americans across the United States. Am J Hum Genet 2015; 96:37–53. [PubMed: 25529636]
39. Peralta CA, Li Y, Wassel C, Choudhry S, Palmas W, Seldin MF, et al. Differences in albuminuria between Hispanics and whites: an evaluation by genetic ancestry and country of origin: the multi-ethnic study of atherosclerosis. Circ Cardiovasc Genet. 2010 Jun;3(3):240–7. [PubMed: 20445135]
40. Astle WJ, Elding H, Jiang T, Allen D, Ruklisa D, Mann AL, et al. The Allelic Landscape of Human Blood Cell Trait Variation and Links to Common Complex Disease. Cell. 2016 Nov 17;167(5):1415–29. [PubMed: 27863252]
41. Jain D, Hodonsky CJ, Schick UM, Morrison JV, Minnerath S, Brown L, et al. Genome-wide association of white blood cell counts in Hispanic/Latino Americans: the Hispanic Community Health Study/Study of Latinos. Hum Mol Genet. 2017 Mar 15;26(6):1193–1204. [PubMed: 28158719]
42. Mensinga TT, Schouten JP, Rijcken B, Weiss ST, van der Lende R. Host factors and environmental determinants associated with skin test reactivity and eosinophilia in a community-based population study. Ann Epidemiol 1994; 4:382–92. [PubMed: 7981846]
43. Puerto Rico (U.S.) Clinician View. 2020.] Available from https://wwwnc.cdc.gov/travel/destinations/clinician/none/puerto-rico.
44. Painter JE, Garagano JW, Collier SA, Yoder JS. Giardiasis Surveillance - United States, 2011–2012. Morbidity and Mortality Weekly Report (MMWR) 2015.

45. Fundora-Hernández H, Venero-Fernández SJ, Suárez-Medina R, Mora-Faife Ede L, García-García G, del Valle-Infante I, et al. What are the main environmental exposures associated with elevated IgE in Cuban infants? A population-based study. Trop Med Int Health 2014; 19:545–54. [PubMed: 24674274]

46. Palmer LJ, Burton PR, Faux JA, James AL, Musk AW, Cookson WO. Independent inheritance of serum immunoglobulin E concentrations and airway responsiveness. Am J Respir Crit Care Med 2000; 161:1836–43. [PubMed: 10852754]

Clinical Implications:

There are racial/ethnic-specific differences in eligibility for asthma biologics among pediatric populations based on commonly used blood parameter thresholds.

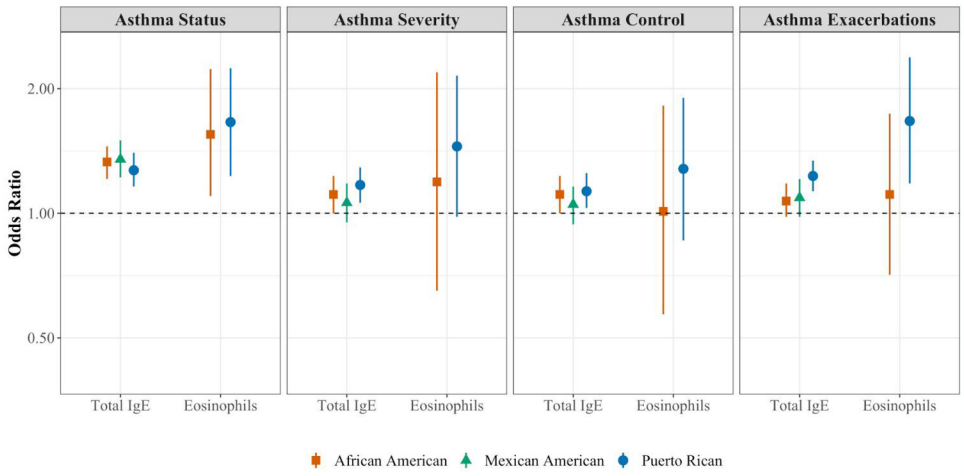

Figure 1. Population-specific adjusted odds ratios for blood parameters on asthma outcomes.

Odds ratios adjusted for age, sex, obesity status, socioeconomic status, and inhaled corticosteroid use within two weeks of recruitment are plotted with their 95% confidence intervals on a log scale. Values shown are associated with a 1-log increase for eosinophils (c/uL) and IgE (kU/L). Odds ratios indicate that the exposure is associated with a poor outcome (asthma/moderate-to-severe asthma/uncontrolled asthma/exacerbations within the past year). Odds ratios for white blood cells in Mexican American children not plotted due to small sample size.

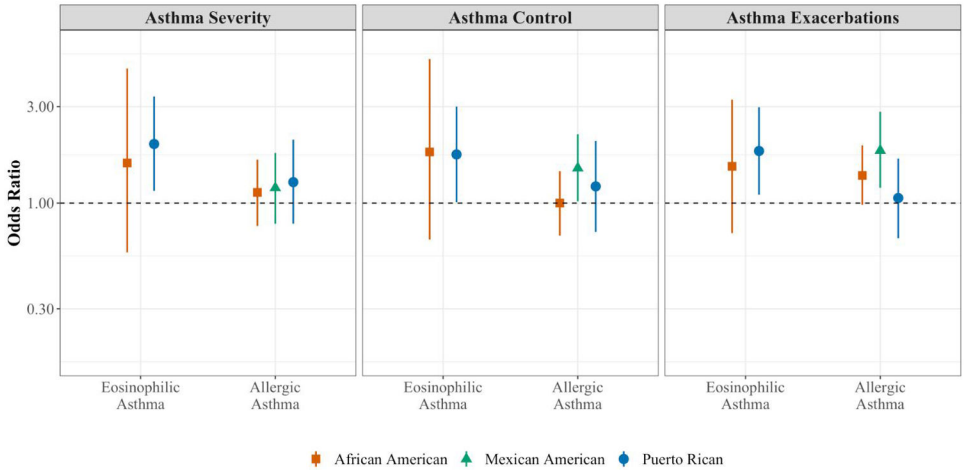

Figure 2. Population-specific adjusted odds ratio for asthma subtypes on asthma outcomes.

Odds ratios adjusted for age, sex, obesity status, socioeconomic status, and inhaled corticosteroid use within two weeks of recruitment are plotted with their 95% confidence intervals on a log scale. Eosinophilic asthma defined as eosinophil count ≥150 c/uL. Allergic asthma was defined as having any sensitization to aeroallergens by skin prick test. Values represent odds of the outcome for a given asthma subtype. Odds ratios indicate that the exposure is associated with a poor outcome (moderate-to-severe asthma/uncontrolled asthma/exacerbations within the past year).

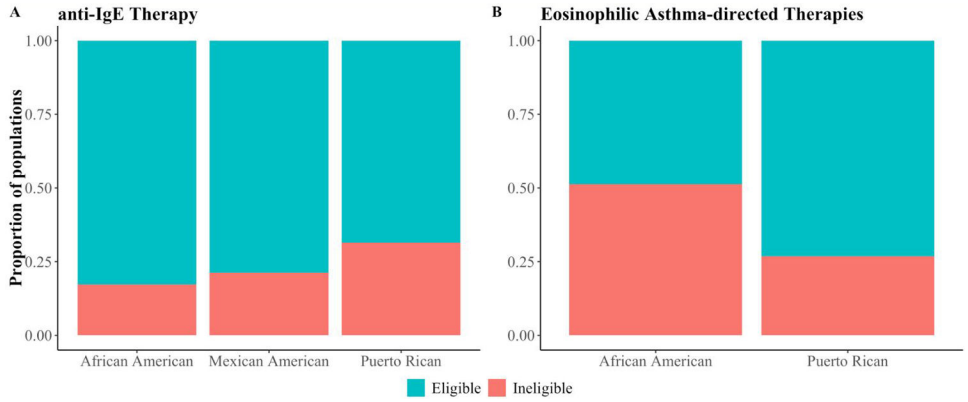

Figure 3. Proportion of study populations that do not meet dosing criteria for IgE targeted therapy or ≥150 c/uL criteria for eosinophilic asthma-directed therapies.

Proportion of participants eligible (teal) or ineligible (salmon) for anti-IgE therapy (A) or eosinophilic asthma-directed therapies with the 150 c/uL cutoff (B).

Table 1.

Distribution of demographic and clinical characteristics for African American, Mexican American and Puerto Rican participants in GALA II and SAGE: 2006–2014

Characteristic*	Total Population (N=3,738)	African American (N=1,275) (34.1%)	Mexican American (N=967) (25.8%)	Puerto Rican (N=1,496) (40.0%)
Median age, yrs (Q_1, Q_3)	13.4 (10.8, 16.8)	14.8 (11.6, 18.1)	13.5 (10.7, 16.9)	12.5 (10.3, 15.3)
Female (n, %)	1,833 (49.0)	642 (50.4)	481 (49.7)	710 (47.5)
Obese (n, %)	1,191 (31.9)	389 (30.5)	362 (37.4)	440 (29.4)
Asthma (n, %)	2,743 (73.4)	898 (70.4)	636 (65.8)	1,209 (80.8)
Moderate-to-Severe asthma† (n, %)	1,917 (70.2)	639 (71.3)	379 (59.7)	899 (74.9)
Uncontrolled asthma† (n, %)	1,957 (71.3)	651 (72.5)	352 (55.3)	954 (78.9)
Exacerbated asthma† (n, %)	1,406 (51.3)	353 (39.3)	214 (33.6)	839 (69.4)
With total IgE measurement (n, %)	3,554 (95.1)	1,267 (99.4)	966 (99.9)	1,321 (88.3)
Median IgE, kU/L (Q_1, Q_3)	169.3 (46.8, 482.8)	138.9 (37.0, 388.6)	121.2 (35.3, 369.2)	271.6 (80.4, 683.6)
With WBC measurements (n, %)	755 (20.2)	251 (19.7)	33 (3.4)	471 (31.5)
Median AEC, c/uL (Q_1, Q_3)	200 (100, 300)	110 (60, 210)	-‡	200 (100, 400)
Eosinophilic asthma§ (n, %)	302 (62.1)	70 (47.6)	-‡	232 (68.4)
With skin prick data (n, %)	2,470 (66.1)	1,083 (84.9)	879 (90.9)	508 (34.0)
Allergic asthma// (n, %)	1,168 (65.9)	483 (65.6)	424 (73.1)	261 (58.9)
SES				
Low (n, %)	1,528 (40.9)	633 (49.6)	418 (43.2)	477 (31.9)
Medium (n, %)	1,522 (40.7)	518 (40.6)	399 (41.3)	605 (40.4)
High (n, %)	688 (18.4)	124 (9.7)	150 (15.5)	414 (27.7)
ICS use within 2 weeks of recruitment (n, %)	719 (19.2)	327 (25.6)	212 (21.9)	180 (12.0)

Abbreviations: Q_1, 1st quartile; Q_3, 3rd quartile; IgE, immunoglobulin E; WBC, white blood cell; AEC, absolute eosinophil count; SES, socioeconomic status; ICS, inhaled corticosteroid

P-values for between population comparisons are provided in Table E2.

*All values shown are N values and percentages of the population with the exception of age, AEC, IgE which represent medians and 1st and 3rd quartiles.

† Expressed as percentage of population with asthma.

‡ Not analyzed due to small sample size.

§ Expressed as percentage of asthma cases with measured eosinophil count. Defined as eosinophil count ≥150 c/uL.

‖ Expressed as percentage of asthma cases with skin prick measurements. Defined as having positive aeroallergen skin prick test.