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Latino-white disparities in ICD-coded asthma diagnosis among US children

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ABSTRACT

Introduction: It is uncertain if disparities in asthma diagnosis between Latino and non-Hispanic white children stem from differences in diagnosis over time among children presenting with similar clinical scenarios suggestive of asthma.

Methods: We evaluated the odds of International Classification of Disease (ICD)-coded asthma diagnosis in Latino (English and Spanish preferring) and non-Hispanic white children, overall ($N=524,456$) and among those presenting with possible asthma indicators ($N=85,516$) over a 13-year period, using electronic health record data from a multi-state network of community health centers.

Results: Among those with possible asthma indicators, Spanish-preferring Latinos had lower adjusted odds of ICD-coded asthma diagnosis compared to non-Hispanic whites ($OR = 0.87$, $95\%CI = 0.77-0.99$); English-preferring Latinos did not differ from non-Hispanic whites. Differences in ICD-coded diagnosis between ethnicity/language groups varied by presenting symptom.

Conclusions: Spanish-preferring Latino children may be less-likely to have ICD-coded asthma documented in the EHR when presenting with certain clinical indicators suggestive of asthma. Clinicians should be cognizant of the need for the follow-up of these indicators in Spanish-preferring Latino children.

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Introduction

Asthma outcome disparities between Latino children and non-Hispanic white children persist in the United States (1–3). Unfortunately, a comprehensive understanding of why this exists along with progress toward ending this persistent health inequity remain elusive. The diagnosis of asthma is the starting point of adequate care for this common chronic condition (4). Some prior studies have found a greater relative prevalence of asthma diagnoses in Latino children compared with non-Hispanic whites (5,6), while others have not (7–9). Numerous factors in national surveys have been shown to be associated with asthma prevalence, including specific Latino subgroup (10–15) and country of birth (16–19).

Some studies have examined the association between symptoms and diagnosis (8,20), but largely utilize patient/family report to establish the diagnosis. Other work has examined odds of asthma diagnosis and wheezing in foreign born children in general (21),

after early life severe respiratory infection (22), and in Latino adolescents with varying levels of acculturation (23), but research correlating presenting symptom with diagnosis of asthma in a healthcare facility is largely not found in the literature, and is an important and missing element of our understanding of asthma disparities. Specifically, it is uncertain if Latino children receive the same documented asthma diagnoses by clinicians, when presenting with comparable clinical situations, as white children. Therefore, a broad, objectively measured examination of a national sample of children, their presenting clinical indicators, and subsequent asthma diagnosis could better elucidate the landscape of healthcare inequity in asthma among Latino children.

To fill this crucial gap, we analyzed a sample of >500 000 low-income children using an electronic health record (EHR) dataset from a 24-state network of community health centers (CHCs) in the United States to examine patient demographics, presenting clinical indicators, and International Classification of

Disease (ICD)-coded asthma diagnosis in >4.8 million encounters over 13 years (2005–2017). Our objective was twofold: 1) to compare the prevalence of ICD-coded asthma diagnosis in both English and Spanish-speaking Latino children and non-Hispanic white children seeking care at CHCs and most importantly 2) to compare this prevalence among children presenting with clinical indicators suggestive of asthma, because this likely represents a population at higher risk for the diagnosis and represents common clinical scenarios encountered by clinicians. Based on limited survey-based evidence on under-diagnosis in Latino children (8,20), we hypothesized that Latino children, both English and Spanish preferring, would have lower adjusted odds of receiving asthma diagnoses when presenting with clinical indicators suggestive of asthma as compared to non-Hispanic white children.

Methods

Study Data. We utilized data from the Accelerating Data Value Across a National Community Health Center Network (ADVANCE) Clinical Research Network (CRN) (24). The ADVANCE CRN contains EHR data from the OCHIN network and Health Choice Network (HCN) of CHCs in 24 states. This dataset includes patients who have at least one ambulatory visit between 1/1/2012–12/31/2017. Once included in the warehouse, data is potentially available as far back as 2005 and through 12/31/2017; all available data were included in the analysis. Community health centers are comprehensive primary care clinics that receive special US government funding to care for low-income populations. They care for over 28 million patients in the United States (25).

Population

Our study population was any Latino or non-Hispanic white child, age 3–17 (26), with an outpatient office visit after January 1, 2012. We excluded children under the age of three because of the frequency of lower respiratory symptoms (e.g. wheeze) in this group that do not eventually result in asthma diagnosis (26). We also considered a subpopulation who presented with at least one indicator consistent with asthma, including wheeze, five or more visits for cough, bronchitis (a term often used to describe lower respiratory symptoms in children with clinical overlap with asthma symptoms (27–29)), and documented albuterol prescription (we term these “clinical indicators”). We chose to include albuterol

prescription given the common practice of prescribing albuterol for symptom treatment even prior to an official diagnosis of asthma (29,30). Multiple presentations for cough were considered as an indicator as this is a presenting symptom of asthma in some children (31). Children with a diagnosis of cystic fibrosis were excluded.

Dependent variable

The primary outcome variable was ICD-9 or ICD-10 diagnosis of asthma, either in a visit or on the child’s EHR problem list (4). **Independent Variables.** Our main independent variable was categorized as three groups: non-Hispanic white patients, Spanish preferring Latino patients, and English preferring Latino patients. While we generally use Latino/a because it is often preferred in populations similar to our study population, the actual ethnicity information collected by clinics is “Hispanic” and “non-Hispanic white” (32). Language preference and ethnicity is assessed routinely at study clinics in the course of routine care.

Covariates

We included EHR-derived age at first encounter, sex, insurance status (never insured at any visits, public insurance at some visits, private insurance at some visits, private and public at some visits), family income measured as % federal poverty level, body mass index (BMI), binary clinical indicators (wheeze, 5+ coughs, bronchitis, albuterol prescription), and rate of ambulatory visits per year. Wheeze, cough, and bronchitis were derived from ICD-9/10 codes at visits, and albuterol was measured using prescription National Drug Codes (NDC) in the EHR medication list. BMI was measured using Centers for Disease Control and Prevention (CDC) standards (33). Overweight at a clinic visit was defined as having a BMI $\geq 85^{\text{th}}$ percentile to $< 95^{\text{th}}$ percentile (for respective age and sex), and obesity at clinic visit was defined as a BMI $\geq 95^{\text{th}}$ percentile. Overweight/obese at a clinic visit was defined as the child’s BMI being $\geq 85^{\text{th}}$ percentile. BMI percentiles and groups were calculated using the R package *childsds*, version 0.6.7, using CDC parameters. We initially derived the rural-urban classification of the clinics study patients attended, but >90% of patients attended clinics in metropolitan or micropolitan areas; we therefore could not include this covariate in our regression models.

Table 1. Pediatric population characteristics, overall and by ethnicity/language.

Demographics	Overall	Ethnicity/Language Groups		
		Non-Hispanic White	Latino Preferring Spanish	Latino Preferring English
N (%)	524,456	176,021	184,728	163,707
Age:				
3-5	193,398 (36.9)	63,136 (35.9)	76,220 (41.3)	54,042 (33.0)
6-11	169,467 (32.3)	55,821 (31.7)	57,366 (31.1)	56,280 (34.4)
11-14	94,028 (17.9)	32,679 (18.6)	29,910 (16.2)	31,439 (19.2)
14-17	67,563 (12.9)	24,385 (13.9)	21,232 (11.5)	21,946 (13.4)
Sex: female	260,366 (49.6)	87,747 (49.9)	90,871 (49.2)	81,748 (49.9)
Insurance: Never Insured	56,064 (10.7)	17,989 (10.2)	24,484 (13.3)	13,591 (8.3)
Some Private	44,924 (8.6)	31,428 (17.9)	5,737 (3.1)	7,759 (4.7)
Some Public	400,345 (76.3)	116,303 (66.1)	148,026 (80.1)	136,016 (83.1)
Some Private and Public	23,123 (4.4)	10,301 (5.9)	6,481 (3.5)	6,341 (3.9)
Federal Poverty Level ² >138%: Yes	316,340 (60.3)	95,743 (54.4)	131,202 (71)	89,395 (54.6)
No	208,116 (39.7)	80,278 (45.6)	53,526 (29)	74,312 (45.4)
Visits Per Year: <1	173,461 (33.1)	69,290 (39.4)	49,951 (27.0)	54,220 (33.1)
1-2	221,903 (42.3)	68,360 (38.8)	84,811 (45.9)	68,732 (42.0)
3-4	71,310 (13.6)	19,802 (11.2)	28,765 (15.6)	22,743 (13.9)
5-9	39,165 (7.5)	11,823 (6.7)	15,113 (8.2)	12,229 (7.5)
>10	18,617 (3.5)	6,746 (3.8)	6,088 (3.3)	5,783 (3.5)
Smoking: Current	2,419 (0.5)	1,767 (1)	249 (0.1)	403 (0.2)
NEI ¹	356,982 (68.1)	116,822 (66.4)	112,549 (60.9)	127,611 (78)
Never	161,789 (30.8)	55,733 (31.7)	71,108 (38.5)	34,948 (21.3)
Past	3,266 (0.6)	1,699 (1)	822 (0.4)	745 (0.5)
Overweight ² : Never	116,022 (22.1)	42,502 (24.1)	41,240 (22.3)	32,280 (19.7)
Sometimes	82,256 (15.7)	22,631 (12.9)	37,176 (20.1)	22,449 (13.7)
Always	98,207 (18.7)	27,690 (15.7)	40,573 (22)	29,944 (18.3)
Missing	227,971 (43.5)	83,198 (47.3)	65,739 (35.6)	79,034 (48.3)
Clinical Indicators				
Wheeze	7,970 (1.5)	2,497 (1.4)	3,726 (2.0)	1,747 (1.1)
5+ Cough	3,295 (0.6)	892 (0.5)	1,446 (0.8)	957 (0.6)
Bronchitis	12,965 (2.5)	4,790 (2.7)	4,829 (2.6)	3,346 (2.0)
Albuterol Prescription	78,891 (15.0)	25,039 (14.2)	31,633 (17.1)	22,219 (13.6)

Note: All chi-square tests for differences between ethnicity/language groups were significant at $p < 0.001$.

¹Not enough information.

²BMI was measured using Centers for Disease Control and Prevention (CDC) standards. Overweight at a clinic visit was defined as having a BMI ≥ 85 th percentile to <95th percentile (for respective age and sex), and obesity at clinic visit was defined as a BMI ≥ 95 th percentile. Overweight/obese at a clinic visit was defined as the child's BMI being ≥ 85 th percentile. BMI percentiles and groups were calculated using the R package *childsds*, version 0.6.7, using CDC parameters.

Analysis

We described patient characteristics in our total sample and compared difference between our three ethnicity/language groups using chi-square tests. Among the full sample, we estimated adjusted odds ratios of having an asthma diagnosis by ethnicity/language groups using logistic regression modeling with a robust sandwich variance estimator to account for clustering of patients within clinics and including the covariates listed above. As secondary analyses, among the subset of patients with clinical indication of asthma, to estimate ICD-coded disparities between ethnicity/language groups, we performed generalized estimating equation (GEE) logistic regression analyses with a working exchangeable correlation structure to accounting for clustering of patients within clinics. In these models, the outcome was ICD-coded asthma diagnosis (yes vs. no) and predictors were ethnicity/language groups, clinical indicators, interaction terms between ethnicity/language groups and clinical indicators (which captured heterogeneity of effects), and the remaining covariates. For all models, we report odds

ratios (ORs) and their corresponding 95% confidence intervals (CIs), accounting for clustering of patients within CHCs. Analyses were performed using Stata version 15 and R version 4.0.2, and statistical significance was set at p values < 0.05 . This study was approved by the Institutional Review Board of Oregon Health and Science University.

Results

Full study population ($N = 524,456$) characteristics, overall and by ethnicity/language groups, are reported in Table 1. Differences were noted in insurance status: Spanish-speaking Latino children were more likely to be uninsured than non-Hispanic white and English-speaking Latino children (13.3%, 10.2%, and 8.3% respectively, $p < 0.001$). Latino children (English and Spanish-speaking) were less likely than non-Hispanic white children to have some private insurance (4.7% and 3.1% to 17.9%, $p < 0.001$), but more likely to have some public insurance (83.1% and 80.1% to 66.1%, $p < 0.001$). Demographics for the subset of children

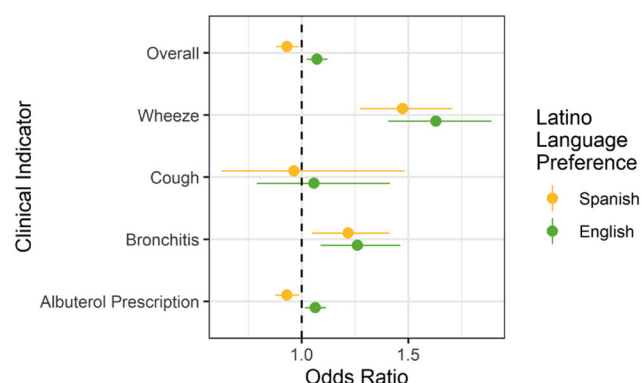


Figure 1. Among children with any clinical indication of asthma ($N = 85,516$), adjusted odds ratios of having an asthma diagnosis comparing Latino Spanish-prefering and Latino English-prefering to non-Hispanic whites. Adjusted odds ratios are reported overall, and for each specific clinical indicator. Note: Estimates were derived using a generalized estimating equation (GEE) logistic regression model with a working exchangeable correlation structure to accounting for clustering of patients within clinics. The outcome was ICD-coded asthma diagnosis (yes vs. no) and predictors were ethnicity/language groups, clinical indicators, interaction terms between ethnicity/language groups and clinical indicators (which captured heterogeneity of effects), and the remaining covariates (age at first encounter, sex, insurance status, family income measured as % federal poverty level, body mass index, and rate of ambulatory visits per year).

with at least one clinical indicator of asthma ($N = 85,516$) are reported in [Appendix Table 1](#).

Among our full study population ($N = 524,456$), each of our ethnicity/language groups had a similar observed unadjusted prevalence of ICD-coded asthma: non-Hispanic white children 10.6%, Spanish-prefering Latino children 10.8%, and English preferring Latino children 10.2%. In the adjusted analyses, Spanish-prefering Latino children had lower odds of being diagnosed with asthma ($OR = 0.75$, 95% $CI = 0.67–0.84$) than non-Hispanic white children, but English preferring Latino children showed similar adjusted odds of having an asthma diagnosis to non-Hispanic white children ($OR = 0.96$, 95% $CI = 0.81–1.14$).

Among children presenting with any clinical indicator ($N = 85,516$), as shown in [Figure 1](#) and [Table 2](#), we observed that Spanish-prefering Latino children have lower adjusted odds of having an asthma diagnosis compared to non-Hispanic white children. English-prefering Latino children had higher odds of an ICD-coded asthma diagnosis than non-Hispanic white children.

When evaluating the odds of ICD-coded asthma diagnosis among children with particular clinical indicators, Latino children in both language groups with a

presentation for wheeze in the study period showed higher odds of receiving an ICD-coded asthma diagnosis compared to non-Hispanic whites. Spanish and English-speaking Latinos had increased odds of receiving an ICD-coded asthma diagnosis compared to non-Hispanic whites when diagnosed with bronchitis. Spanish-speaking Latino had lower odds of ICD-coded asthma diagnosis when receiving an albuterol prescription and English-preferring Latino children had higher odds compared to non-Hispanic whites. No differences in the adjusted odds of ICD-coded asthma diagnosis between ethnicity/language groups was observed among those presenting with 5+ coughs.

Discussion

This study is novel in its use of longitudinal EHR data from a large sample of patients to study ethnic/language differences in asthma diagnosis, and specifically among children presenting to their community health center with possible clinical indicators of asthma. Our intention was not to establish the diagnosis of asthma against a gold standard, or to assess the prediction of asthma diagnosis by these clinical indicators, but to compare the prevalence of ICD-coded chart diagnosis in similar, EHR documented clinical presentations across our population, which is a significant advancement over previous diagnosis literature which has relied mainly on self-report. Demonstrating different pathways from presenting indicator to chart diagnosis can provide greater understanding of future targets for equitable treatment in asthma. Overall, Spanish-prefering Latino children had a lower adjusted odds of ICD-coded asthma diagnosis, even when having at least one possible presenting symptom of asthma. This result, in a large sample of symptomatic children and adjusting for health care access, challenges previous findings about asthma prevalence which suggests that ethnicity alone may be the major driver of diagnosis differences (5,6). Our findings suggest that differences in prevalence of asthma diagnosis may be more across language groups rather than ethnic ones, and those differences persist even when clinical suspicion for asthma is higher (because possible clinical indicators are present). Prior studies noted lower odds of asthma diagnosis in Spanish-prefering families (34); our study found similar results in a larger, national sample using electronic health record data. Further work can examine the specific Hispanic subgroup or nativity represented by the language groups.

Table 2. Among children with any clinical indication of asthma ($N = 85\,516$), adjusted odds ratios of having an asthma diagnosis comparing Latino Spanish-preferred and Latino English-preferred to non-Hispanic whites.

Clinical Presentation	Non-Hispanic White	Hispanic Spanish-preferred	Hispanic English-preferred
Any	Ref	0.93 (0.88-0.99)	1.07 (1.02-1.12)
Wheeze	Ref	1.47 (1.27-1.71)	1.63 (1.40-1.89)
5+ Cough	Ref	0.96 (0.63-1.48)	1.06 (0.79-1.41)
Bronchitis	Ref	1.22 (1.05-1.41)	1.26 (1.09-1.46)
Received albuterol prescription	Ref	0.93 (0.88-0.99)	1.06 (1.02-1.11)

Adjusted odds ratios are reported overall, and for each specific clinical indicator. Adjusted odds ratios and corresponding 95% confidence intervals (in parentheses) are reported.

Note: Estimates were derived using a generalized estimating equation (GEE) logistic regression model with a working exchangeable correlation structure to accounting for clustering of patients within clinics. The outcome was ICD-coded asthma diagnosis (yes vs. no) and predictors were ethnicity/language groups, clinical indicators, interaction terms between ethnicity/language groups and clinical indicators (which captured heterogeneity of effects), and the remaining covariates (age at first encounter, sex, insurance status, family income measured as % federal poverty level, body mass index, and rate of ambulatory visits per year). Bold denotes statistical significance ($p < 0.05$).

Interestingly, we found that differences in asthma diagnosis between ethnicity/language groups varied by clinical indicator. Most prominently, Spanish-preferred Latinos who had received an albuterol prescription had lower odds of ICD-coded asthma diagnosis than English-preferred Latinos or non-Hispanic whites. Given the high proportion of our sample who had received these prescriptions (See [Appendix Table 1](#)), this clinical situation likely greatly contributed to the overall pattern (reduced odds in Spanish-preferred Latinos) in the symptomatic sample. Lower odds of ICD-coded asthma diagnosis in Spanish-preferred children who receive prescriptions for albuterol raise the concern that when albuterol is prescribed for acute symptoms (which is a common clinical pattern, as evidenced by a Cochrane review (30), there may be language barriers to follow-up on the response to that medication and whether asthma should be considered as a diagnosis. Alternatively, there may be other barriers to follow-up in this language group that we did not measure in our analysis. Transportation barriers, other socioeconomic barriers to access, or provider bias may impact follow up in this setting and can be foci of future research. The albuterol prescription patterns may also reflect that albuterol is prescribed for multiple specific scenarios (including our other clinical indicators), so reflects the trends in the larger study population and does not reflect patterns in the care of one specific symptom. Regardless, to ensure appropriate diagnosis, our findings suggest that providers should be specifically attuned to recommending follow up to Spanish-preferred children who are prescribed albuterol in the acute setting.

In contrast, Latino children with wheeze or bronchitis diagnoses, regardless of language, were more likely to have an ICD-coded asthma diagnosis than non-Hispanic white children. While our findings raise concern for a scenario whereby some Latino children may not be receiving asthma diagnoses, this result

suggests that there may be scenarios in which the providers of Latino children are more likely to diagnose asthma. Reasons for this are uncertain; it may be that these obvious lower respiratory tract symptoms raise particular concern with families and providers for this population and therefore lead to higher odds of diagnosis. Recurrent cough may not generate this elevated suspicion, as both Spanish and English-preferred Latino children did not differ in from non-Hispanic white children in this category. Regardless of the specific dynamics that produce differential diagnosis rates with different clinical indicators, the variation observed in this study suggests that disparities in asthma outcomes in Latino children are not homogenous; they depend on language and on the specific presenting scenario. Finally, it is also important to observe the absolute number of children, including children with asthma, across demographic characteristics who receive care at community health centers. This volume suggests that this piece of the healthcare safety net is vital to children's health in the United States.

While our findings are specific to a sub-population in the United States (Latino children with asthma), there may be lessons for other disease processes in other settings. Namely, that inequalities in care for conditions treated in primary care may be varied; specific clinical scenario, specific sub-population, and complex social factors all may affect the delivery of routine primary care and result in inequity. It is incumbent upon providers and policy makers to appreciate this complexity, and turn our clinical and research efforts toward understanding the details of clinical scenarios such as these as much as possible.

Limitations

Limitations to our analysis include that we did not have definitive testing information (spirometry), so

our diagnosis odds are relative to a comparison group, and not to a diagnostic gold standard. Our outcome of EHR diagnosis, when compared to true diagnosis (measured by a gold standard) may produce overestimation (falsepositive cases) or underestimation (false-negative cases) and could therefore be a source for information bias. However, our aim was not to validate these indicators as predictors of true asthma diagnosis. Rather, it was to compare odds of chart diagnoses with these clinical indicators consistent with asthma between our ethnic/language cohorts. Previous studies in the US have not looked at these scenarios in this manner, and most previous survey-based research on asthma has used far less stringent criteria for asthma diagnosis (2,5,7). Future research can investigate the association between ethnicity/language, symptoms, and spirometric diagnosis of asthma; our data may provide a foundation for whom to target with confirmatory testing. We set five episodes of cough as a marker of recurrent cough, but findings could change as this threshold is moved up or down. Our records only include what has been entered into the ambulatory EHR, and may not include events or information from emergency department or urgent care visits. Asthma clinical indicators were recorded at any time in the observation period and these indicators of asthma may have occurred after diagnosis, though this would have little impact on our conclusions. Specific ethnic subgroup (Mexican, Puerto Rican, etc.) and nativity may play a significant role in the prevalence of asthma diagnoses in Latino children, but we could not evaluate that in this analysis as the EHR does not contain consistent record of this information. However, our focus on broader ethnic/language categories would seem appropriate because 1) currently, providers may be more likely to have general ethnic information about their patient panels to make inferences about the risk of chronic disease and 2) our focus on presenting indicator addresses patterns of provider behavior, not overall disease prevalence. Further investigation using ethnic subgroup may yield important additional information about differential diagnosis rates, and future work can apply our methods here to subsets containing that subgroup data. We did not analyze non-Hispanic black children, as disparities in Latino children potentially encompass distinct issues from those faced in African-American communities. We did not have data on the language preference of clinicians, a factor which could also influence rates of ICD-coded diagnosis and follow-up and should be further examined in future work. Finally, we did not

have direct information from caregivers about perceptions or communication regarding diagnosis.

Conclusion

In a large, geographically disparate sample of children presenting at community health centers, Spanish-preferring Latino children were less likely and English-speaking Latino children were more likely to have an ICD-coded asthma diagnosis than and non-Hispanic white children when presenting with a clinical indicator suggestive of asthma. Odds of diagnosis differed by specific indicator, however, with Spanish and English preferring Latino children having higher odds than non-Hispanic white children when presenting with wheeze or bronchitis, but not when presenting with recurrent cough. Spanish-preferring Latino children had lower odds of ICD-coded diagnosis than non-Hispanic white children when prescribed albuterol. Our findings suggest that providers should be especially attuned to Latino children – especially Spanish-preferring children – when prescribing albuterol for acute symptoms prior to asthma diagnosis. Closer follow up to ensure appropriate asthma diagnosis is also likely needed. Future research should build upon these results to examine time course from symptoms to diagnosis, as well as interpersonal clinician-patient-family factors that may affect communication about symptoms and diagnosis.

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Declaration of interest

The authors listed above have no conflicts of interest, real or perceived.

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References

- Canino G, McQuaid EL, Rand CS. Addressing asthma health disparities: a multilevel challenge. *J Allergy Clin Immunol*. 2009;123(6):1209–1217. quiz 18–9. doi:10.1016/j.jaci.2009.02.043.
- Akinbami LJ, Simon AE, Rossen LM. Changing trends in asthma prevalence among children. *Pediatrics*. 2016;137(1):e20152354. doi:10.1542/peds.2015-2354.
- National Heart Lung, and Blood Institute. Reducing asthma disparities 2012. Available from: <https://www.nhlbi.nih.gov/health-pro/resources/lung/naci/discover/disparities.htm> [last accessed 1 September 2020].
- National Heart, Lung, and Blood Institute. Expert Panel Report 3: guidelines for the diagnosis and management of asthma; 2007.
- Akinbami LJ, Rhodes JC, Lara M. Racial and ethnic differences in asthma diagnosis among children who wheeze. *Pediatrics*. 2005;115(5):1254–1260. doi:10.1542/peds.2004-0897.
- Stewart KA, Higgins PC, McLaughlin CG, Williams TV, Granger E, Croghan TW. Differences in prevalence, treatment, and outcomes of asthma among a diverse population of children with equal access to care: findings from a study in the military health system. *Arch Pediatr Adolesc Med*. 2010;164(8):720–726. doi:10.1001/archpediatrics.2010.100.
- Oraka E, Iqbal S, Flanders WD, Brinker K, Garbe P. Racial and ethnic disparities in current asthma and emergency department visits: findings from the National Health Interview Survey, 2001–2010. *Journal of Asthma*. 2013; 50(5):488–496. doi:10.3109/02770903.2013.790417.
- Bruzzese JM, Kingston S, Falletta KA, Bruzelius E, Poghosyan L. Individual and neighborhood factors associated with undiagnosed asthma in a large cohort of urban adolescents. *J Urban Health*. 2019;96(2): 252–261. doi:10.1007/s11524-018-00340-2.
- Meng YY, Babey SH, Hastert TA, Brown ER. California's racial and ethnic minorities more adversely affected by asthma. UCLA Center for Health Policy Research. 2007. Available from: <http://healthpolicy.ucla.edu/publications/Documents/PDF/California%27s%20Racial%20and%20Ethnic%20Minorities%20More%20Adversely%20Affected%20by%20Asthma.pdf> [last accessed 1 September 2020].
- Camacho-Rivera M, Kawachi I, Bennett GG, Subramanian SV. Revisiting the Hispanic health paradox: the relative contributions of nativity, country of origin, and race/ethnicity to childhood asthma. *J Immigr Minor Health*. 2015;17(3):826–833. doi:10.1007/s10903-013-9974-6.
- Lara M, Akinbami L, Flores G, Morgenstern H. Heterogeneity of childhood asthma among Hispanic children: Puerto Rican children bear a disproportionate burden. *Pediatrics*. 2006;117(1):43–53. doi:10.1542/peds.2004-1714.
- Subramanian SV, Jun HJ, Kawachi I, Wright RJ. Contribution of race/ethnicity and country of origin to variations in lifetime reported asthma: evidence for a nativity advantage. *Am J Public Health*. 2009; 99(4): 690–697. doi:10.2105/AJPH.2007.128843.
- Dumanovsky T, Matte TD. Variation in adult asthma prevalence in Hispanic subpopulations in New York City. *J Asthma*. 2007;44(4):297–303. doi:10.1080/02770900701344140.
- 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;(94):1–8.
- Rose D, Mannino DM, Leaderer BP. Asthma prevalence among US adults, 1998–2000: role of Puerto Rican ethnicity and behavioral and geographic factors. *Am J Public Health*. 2006;96(5):880–888. doi:10.2105/AJPH.2004.050039.
- Holguin F, Mannino DM, Antó J, Mott J, Ford ES, Teague WG, Redd SC, Romieu I. Country of birth as a risk factor for asthma among Mexican Americans. *Am J Respir Crit Care Med*. 2005;171(2):103–108. doi:10.1164/rccm.200402-143OC.
- Eldeirawi K, McConnell R, Freels S, Persky VW. Associations of place of birth with asthma and wheezing in Mexican American children. *J Allergy Clin Immunol*. 2005;116(1):42–48. doi:10.1016/j.jaci.2005.03.041.
- Eldeirawi KM, Persky VW. Associations of acculturation and country of birth with asthma and wheezing in Mexican American youths. *J Asthma*. 2006;43(4): 279–286. doi:10.1080/0277090060022869.
- Iqbal S, Oraka E, Chew GL, Flanders WD. Association between birthplace and current asthma: the role of environment and acculturation. *Am J Public Health*. 2014;104(S1):S175–S82. doi:10.2105/AJPH.2013.301509.
- Yeatts K, Davis KJ, Sotir M, Herget C, Shy C. Who gets diagnosed with asthma? Frequent wheeze among adolescents with and without a diagnosis of asthma. *Pediatrics*. 2003;111(5 Pt 1):1046–1054. doi:10.1542/peds.111.5.1046.
- McRoy L, Ramamonjiravelo Z, Epané J, Powers M, Xu J, Weech-Maldonado R, Rust G. Country of birth and variations in asthma and wheezing prevalence, and emergency department utilization in children: a NHANES study. *J Immigr Minor Health*. 2017;19(6): 1290–1295. doi:10.1007/s10903-016-0459-2.
- Wohlford EM, Borrell LN, Elhawary JR, Plotkin B, Oh SS, Nuckton TJ, Eng C, Salazar S, LeNoir MA, Meade K, et al. Differential asthma odds following respiratory infection in children from three minority populations. *PLoS One*. 2020;15(5):e0231782. doi:10.1371/journal.pone.0231782.
- Thakur N, Borrell L, Ye M, Oh S, Eng C, Meade K, Avila P, Farber H, Serebrisky D, Brigino-Buenaventura E, et al. Acculturation is associated with asthma burden and pulmonary function in Latino youth: the GALA II study. *J Allergy Clin Immunol*. 2019;143(5):1914–1922. doi:10.1016/j.jaci.2018.12.1015.
- DeVoe JE, Gold R, Cottrell E, Bauer V, Brickman A, Puro J, Nelson C, Mayer KH, Sears A, Burdick T, et al. The ADVANCE network: accelerating data value across a national community health center network. *J Am Med Inform Assoc*. 2014;21(4):591–595. doi:10.1136/amiajnl-2014-002744.
- National Association of Community Health Centers. Community Health Center Chartbook; 2019. <http://>

- www.nachc.org/wp-content/uploads/2019/01/Community-Health-Center-Chartbook-FINAL-1.28.19.pdf.
26. British Medical Journal. BMJ best practice: asthma in children; 2018. <https://bestpractice.bmj.com/topics/en-us/782>.
 27. Morgan JR, Carey KM, Barlam TF, Christiansen CL, Drainoni ML. Inappropriate antibiotic prescribing for acute bronchitis in children and impact on subsequent episodes of care and treatment. *Pediatr Infect Dis J*. 2019;38(3):271–274. doi:10.1097/INF.0000000000002117.
 28. Berhane K, Chang C-C, McConnell R, Gauderman WJ, Avol E, Rapaport E, Urman R, Lurmann F, Gilliland F. Association of changes in air quality with bronchitic symptoms in children in California, 1993–2012. *JAMA*. 2016;315(14):1491–1501. doi:10.1001/jama.2016.3444.
 29. British Medical Journal. BMJ Best Practice. Acute Bronchitis; 2018 [accessed 11/3/20] <https://bestpractice.bmj.com/topics/en-us/135>.
 30. Tomerak AAT, Vyas HHV, Lakhanpaul M, McGlashan J, McKean MC. Inhaled beta2-agonists for non-specific chronic cough in children. *Cochrane Database Syst Rev*. 2005;(3):CD005373. doi:10.1002/14651858.CD005373.
 31. Spelman R. Two-year follow up of the management of chronic or recurrent cough in children according to an asthma protocol. *Br J Gen Pract*. 1991;41(351):406–409.
 32. Zambrana RE, Carter-Pokras O. Health data issues for Hispanics: implications for public health research. *J Health Care Poor Underserved*. 2001;12(1):20–34. doi:10.1353/hpu.2010.0547.
 33. Center for Disease Control and Prevention. Citation. Defining childhood obesity. [accessed November 13, 2020]. <https://www.cdc.gov/obesity/childhood/defining.html>.
 34. Mosnaim GS, Sadowski LS, Durazo-Arvizu RA, Sharp LK, Curtis LM, Shalowitz MU, Shannon JJ, Weiss KB. Parental language and asthma among urban Hispanic children. *The J Allergy Clin Immunol*. 2007;120(5):1160–1165. doi:10.1016/j.jaci.2007.08.040.

Appendix

The equations of the model used to derive the estimates of the odds of asthma diagnosis took the form:

$$\log\left(\frac{P}{1-P}\right) = \beta_0 + \beta_1 \text{Latino} : \text{English Preference} + \beta_2 \text{Latino} : \text{Spanish Preference} + \gamma Y$$

where P is the probability of asthma diagnosis, β_0 is the intercept, β_1 is the coefficient for the indicator of being Latino: English Preference, β_2 is the coefficient for the indicator of a patient being Latino: Spanish preference and the reference group is set to non-Hispanic whites. The vector γ is a set of coefficients that correspond to the matrix Y of covariates. The covariates for all equations were: age, female sex, insurance status, visits per year, cough, bronchitis, albuterol prescription wheeze, overweight status, and federal poverty status.

Appendix Table 1. Pediatric population characteristics among children with any clinical indication of asthma, overall and by ethnicity/language. *Column percentages shown.*

	Ethnicity/Language Groups			
	Overall	Non-Hispanic White	Latino Preferring Spanish	Latino Preferring English
	85,516	27,887	33,669	23,960
Demographics				
Age: 3-5	57.3	50.4	55.4	64.4
6-11	27.8	30.3	28.6	25.2
11-14	10.2	13.3	10.8	7.3
14-17	4.7	6.0	5.2	3.2
Sex: female	45.5	45.7	45.7	45.1
Insurance: Never Insured	3.7	3.2	3.3	4.3
Some Private	7.0	14.6	5.3	1.9
Some Public	81.7	71.9	83.2	88.8
Some Private and Public	7.6	10.4	8.1	5.0
Federal Poverty Level/ >138%: Yes	67.8	62.4	75.6	63.2
No	32.2	37.6	24.4	36.8
Visits Per Year: <1	13.9	18.9	15.1	8.9
1-2	46.7	48.0	47.1	45.5
3-4	23.2	19.7	22.3	26.7
5-9	13.0	10.5	12.2	15.6
>10	3.2	3.0	3.3	3.2
Smoking: Current	0.6	1.3	0.1	0.3
NEI ¹	65.7	67.5	59.3	72.5
Never	32.9	29.7	40.1	26.5
Past	0.9	1.4	0.5	0.7
Overweight: Never	25.8	28	24.1	25.6
Sometimes	31.5	26.1	36.9	30.2
Always	22.5	19.9	23.8	23.7
Missing	20.2	26	15.2	20.5
Clinical Indicators				
Wheeze	9.3	9	11.1	7.3
5+ Cough	3.9	3.2	4.3	4
Bronchitis	15.2	17.2	14.3	14
Albuterol Prescription	92.3	89.8	94	92.7
Asthma	54.2	53.8	52.6	57.0

¹Not enough information.

The subsequent models of clinical asthma indicator-specific odds were of the form:

$$\log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 \text{Latino} : \text{English Preference} + \beta_2 \text{Latino}$$

$$: \text{Spanish Preference} + \beta_3 \text{Latino}$$

$$: \text{English Preference} * \text{Clinical Indicator} + \beta_4 \text{Latino}$$

$$: \text{Spanish Preference} * \text{Clinical Indicator} + \gamma Y$$

where the meaning is the same as in the general model and β_3 and β_4 are the coefficients for the interactions between the Latino patient subgroups and the clinical indicator (i.e. wheeze, 5+ cough, bronchitis, and albuterol prescription). The coefficients of interest here were β_3 and β_4 which captured heterogeneity of effects.