



# Burden of Illness, Primary Care Use, and Medication Utilization among US-México Border Children with Wheezing

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## Abstract

**Objective** Among high-risk, underserved populations, such as children living along the US-México border, suffering from asthma-like symptoms without an asthma diagnosis can result in a high burden of illness. We estimated the prevalence of physician-diagnosed and possible undiagnosed asthma among students with histories of wheezing in the US-México border community of El Paso, Texas, and evaluated their burden of illness, primary care use, and medication utilization.

**Methods** We analyzed cross-sectional survey data collected in May 2012. The survey included validated International Study of Asthma and Allergies in Childhood (ISAAC) items. We performed bivariate and logistic regression analyses on data from 307 students who wheezed.

**Results** Forty-two percent of students had possible undiagnosed asthma and 58% had physician-diagnosed asthma based on primary caretaker reports. Children of Mexican origin were more likely to report undiagnosed vs. diagnosed asthma ( $p < 0.05$ ). Children with an asthma diagnosis were more likely to report any medication use for wheezing/asthma and to experience a higher burden of illness in the last year compared to students with possible undiagnosed asthma ( $p < 0.05$ ).

**Conclusions** The burden of illness among these children was high; however, children with asthma-like symptoms were not faring worse than children with asthma symptoms and a diagnosis. Undiagnosed children were being evaluated and receiving treatment for their symptoms; however, by not receiving a diagnosis, they were eliciting an ameliorative rather than preventive treatment strategy.

**Keywords** Undiagnosed asthma · Asthma burden · Respiratory outcomes · Racial disparities

## Introduction

Asthma affects as many as 10.5 million children (1 in 11) in the USA [1], many of whom are from racial/ethnic minority backgrounds. The burden of disease is of particular concern among high-risk, underserved populations, such as children living along the US-México border, where extrinsic factors may impede the assessment of symptoms, subsequent diagnosis, and the start of treatment [2, 3]. In what follows, we first estimate the prevalence of diagnosed and possible undiagnosed asthma (“asthma status”) among elementary school students with a history of wheezing in the US-México border city of El Paso, Texas. We then compare children across a host of

relevant indicators (e.g., health insurance status) based on asthma status, before predicting their burden of illness, primary care use, and medication utilization based on their asthma status and other relevant characteristics. A focus on asthma status is warranted and critically important given differences in asthma rates between racial/ethnic groups, specifically lower rates of asthma for Hispanics in the USA.

Whereas estimates for the prevalence and burden of illness among those with asthma are well established [4, 5], estimates among those with undiagnosed asthma, herein used to describe the presence of asthma-like symptoms without an asthma diagnosis, are less precise. Some estimate an underdiagnosis of asthma ranging between 30 and 40% among children [6], leading to unanswered questions about the magnitude and severity of unmeasured and unaccounted for respiratory problems among children who are underdiagnosed and undertreated. While a growing body of research suggests a comparability of asthma burden between children with diagnosed and undiagnosed asthma [7], there are consequences to suffering from asthma-like symptoms without an asthma diagnosis, since effective treatments and symptom management usually accompany a diagnosis.

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Undiagnosed asthma can be associated with limitations in daily activities, permanent damage and scarring to lungs, and a higher burden of illness throughout life [8].

Better prevalence estimates and a comprehensive consideration of factors that are associated with undiagnosed asthma are needed to ensure that those who experience respiratory distress obtain the necessary treatment to manage symptoms throughout the lifespan. This is especially relevant along the US-México border, a region that stretches over 2000 miles from California through Texas. The region's population exhibits lower levels of education and income, health insurance and access to health care, and higher rates of unemployment and poverty status; all are factors expected to correlate with higher rates of chronic conditions like asthma [9, 10]. In Texas, the Department of State Health Services reported that 7.8% of children have asthma, with rates higher among black children than among Hispanic and white children [11]; 2012 data also describe 13% of children without health insurance in the state [12]. In Health Service Region 10, which includes El Paso County (the site of this study), the children's asthma hospitalization rate is 17.8 per 10,000 and is the fifth highest in the state [11]. Scholarship in this area suggests that asthma hospitalization rates are increasing [13].

These trends are striking given that among Hispanics, namely those of Mexican origin, asthma rates are traditionally low [14]. The Hispanic epidemiologic paradox (HEP) describes the contradiction of lower rates of adverse health outcomes, including asthma, among Hispanics than among other ethnic groups in the USA [15, 16]. Some researchers suggest that the lower prevalence of asthma among those of Mexican descent may result from underdiagnosis of asthma symptoms rather than an absence of asthma [17, 18]. Prior scholarship in this population demonstrated a prevalence of lifetime asthma of 17% and that of possible undiagnosed asthma of about 7% [19]. These estimates are far above those for lifetime asthma in children in Texas and also higher than those described by the Texas Department of State Health Services for children in El Paso County, where an estimated 8% of children have ever been diagnosed with asthma and 4.5% have current asthma [19, 20]. This suggests that the burden of illness in this population may be higher than official estimates indicate and underscores the importance of examining variations in children's asthma burden as underreporting of symptoms can lead to inappropriate medication use [21].

## Materials and Methods

### Study Area

The study took place in the El Paso Independent School District (EPISD) in El Paso County (EPC), Texas. EPC is located in west Texas along the US-México border and shares

a border with Ciudad Juárez, Chihuahua, México. Approximately 82% of the county's 800,000 plus residents are Hispanic and 78% of those are of Mexican descent [22]. The median household income of EPC residents (\$40,157) was lower than that of residents in the State of Texas (\$51,900) and the USA (\$53,046) [23].

### Study Design and Subjects

Participants are comprised of respondents to a survey of primary caretakers (parents and guardians) of 4th and 5th grade students in the EPISD. Households were sent study materials in three waves during May 2012, in line with the tailored design method, an approach developed to foster high response rates through personalization, follow-up, and small incentives [24]. The first mailing to all households (6295) of 4th and 5th grade EPISD students included a survey packet with materials in English and Spanish; the packet included a close-ended questionnaire, a letter of consent, a postage-paid return envelope, and a \$2 token of appreciation, to be completed and returned by the student's primary caretaker. Consent to participate was established by completing and returning the survey to the study research team. This was followed a week later with a bilingual reminder postcard mailed a week later. Another survey packet with the aforementioned materials, \$2 incentive and postage paid envelope was mailed the third week, resulting in a final response rate of 30.2% (1904/6295).

Descriptive statistics demonstrate that the demographic characteristics of survey respondents are similar to that of the student population throughout EPISD [25]. For the purposes of the present study, these analyses are limited to the 307 children with wheezing symptoms (in the last 12 months). The Institutional Review Board (IRB) at [omitted for peer review] and then [omitted for peer review] reviewed and approved the protocol for this study. Informed consent was obtained from all participants. Cases with missing data were excluded from these analyses, and a complete case analysis was performed.

### Measures

The survey instrument asked detailed questions about the child's respiratory history, including wheezing and asthma symptoms, in line with the International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire [26]. The ISAAC questionnaire is a valid instrument for determining asthma symptoms in past 12 months and has been found to have sensitivity and specificity of 0.85 (0.73–0.93) and 0.81 (0.76–0.86), respectively, as well as test-retest reproducibility [27]. Table 1 shows descriptive statistics for all variables. Primary caretaker responses on the ISAAC questionnaire were used to categorize children's asthma status as having possible undiagnosed asthma or physician-diagnosed asthma. Specifically, the report of asthma-like symptoms (coughing,

**Table 1** Descriptive statistics of analysis variables

	Total N	Mean (SD) or %	Missing (%)
<i>Individual characteristics</i>			
Age (range, 9–13)	300	10.4 (0.8)	2%
Gender (male)	303	58%	1%
Child's history of allergies	297	81%	3%
Child's nativity, US-born	302	95%	2%
Hispanic	303	80%	1%
Mexican origin	296	72%	4%
Survey language (English)	307	76%	0%
Maternal education			0%
Less than high school	20	7%	
High school graduate	62	20%	
College/technical school	158	51%	
Graduate/Professional	67	22%	
Maternal nativity, US-born	283	63%	8%
<i>Environmental factors</i>			
Household smoking in the last 12 months	299	8%	3%
<i>Health care system factors</i>			
Insurance coverage in the last 12 months	307	90%	0%
Regular doctor in the last 12 months	304	96%	1%
Postponement of care due to costs	304	33%	1%
<i>Asthma-specific variables</i>			
Primary care use for wheezing/asthma	168	70%	22%
Any medication utilization use for wheezing or asthma	270	86%	12%
Asthma status (diagnosed)	295	58%	4%
≥ 1 wheezing attacks	302	87%	2%
≥ 1 missed school days	276	51%	10%
≥ 1 sleep disturbance	300	45%	2%
Wheezing limited speech	305	12%	1%

wheezing or whistling in the chest, shortness of breath, chest tightness or phlegm when one does not have a cold or respiratory infection) without a physician diagnosis was used to indicate possible undiagnosed asthma, whereas an affirmative response to “Has the child ever been told by a doctor or other health professional that he or she has asthma?” was used to indicate those who had been diagnosed with asthma [27]. This variable is the focus of the univariate analysis; it serves as a dependent variable in the bivariate analysis, and as an independent variable in the multivariate analysis.

The following serve as independent variables in the bivariate and multivariate analyses and are factors known to be associated with respiratory outcomes: age, the child's history of allergies (1 = yes, 0 = no), child's nativity (1 = US-born, 0 = foreign-born), race/ethnicity (1 = Hispanic, 0 = non-Hispanic), whether the child is of Mexican Origin (1 = yes, 0 = no), the survey language used (1 = English, 0 = Spanish), the mother's highest level of education (0 = less than high school, 1 = high school graduate, 2 = college/technical schooling, 3 = professional/graduate training), mother's nativity (1 = US-born, 0 =

foreign-born), smoke exposure in the home in the last year (1 = yes, 0 = no), insurance coverage in the last year (1 = yes, 0 = no), whether the child had regular access to a doctor in the last 12 months (1 = yes, 0 = no), acute care use at an urgent care center, hospital emergency department or hospitalization for wheezing or asthma doctor in the last 12 months (1 = yes, 0 = no), and whether the family postpones or does not seek medical treatment due to cost (1 = yes, 0 = no) [2, 28].

The following are independent variables in the bivariate analysis and dependent variables in the multivariate analysis. They include primary caretaker reports of burden of illness, primary care use, and medication utilization, which have been examined in previous studies of the impacts of both diagnosed and undiagnosed asthma on school children [5, 8].

Burden of illness was operationalized as four indicators: the frequency of wheezing attacks, sleep disturbance, speech limitations, and missed school days due to wheezing or asthma in the last year. These came from caretaker responses to: “How many attacks of wheezing has your child had in the last 12 months?” “In the last 12 months, how often, on average,

has your child's sleep been disturbed due to wheezing?" "In the last 12 months, has wheezing ever been severe enough to limit your child's speech to only one or two words at a time between breaths?" and "In the past 12 months, how many days (or part days) of school has your child missed because of wheezing or asthma?" Due to small counts, responses were each collapsed into 0 vs.  $\geq 1$  during the past year.

For primary care use for wheezing/asthma, responses to "In the past 12 months, how many visits has your child made to any of the following health care professionals for wheezing or asthma?" were used to distinguish primary care use. Specifically, the count of primary care visits with a "doctor in a clinic" for episodes of wheezing or asthma was dichotomized to 0 vs.  $\geq 1$  during the past year.

For medication utilization, responses to "in the past 12 months, has your child used any medicines, pills, inhalers/puffers or other medication for wheezing or asthma?" and "which medications has your child taken? How often?" were used to indicate any medication use and medication type used in the last year.

## Statistical Analyses

The analyses took place in three steps. First, we determined the percentages of children with each asthma status. Second, we compared children based on their asthma status using all other variables. To test for significance, we used chi-square and Fisher's exact tests for categorical variables and *t* tests for normally distributed continuous variables. Third, we used a stepwise approach to estimate multivariate logistic regression models for each dependent variable that exhibited a statistically significant bivariate association with asthma status, which included wheezing attacks, sleep disturbance, and any medication utilization. Inclusion was set at  $p < 0.21$  and exclusion was set at  $p > 0.20$  in line with standard statistical procedures [29].

While most variables had less than 5% of missing values, there were notable exceptions (see Table 1), namely, primary care use for wheezing (missing 22%) and any medication use (12%) in the last year. Because we could not assume that the data for these analyses were missing at random, we chose to exclude cases with missing values using listwise deletion rather than apply multiple imputation techniques, as other scholars who have examined childhood asthma status have done [30]. Multicollinearity was assessed using the variance inflation factor (VIF); values greater than 10 were removed from the models. Results from the logistic regression models are presented as odds ratios (ORs) with corresponding 95% confidence intervals (CIs). Statistical significance was assessed based on a *p* value of 0.05 or less.

## Results

**Univariate Results** Our sample was comprised of  $n = 307$  students with a history of wheezing/asthma symptoms (coughing, wheezing or whistling in the chest, shortness of breath, chest tightness or phlegm when one does not have a cold or respiratory infection) currently or in the previous 12-month period. Overall, 42% of students had possible undiagnosed asthma and 58% had physician-diagnosed asthma based on primary caretaker reports (see Table 1).

**Bivariate Results** Compared to children with possible undiagnosed asthma (71%), a higher proportion of children with physician-diagnosed asthma (89%) reported a history of allergies during the 12-month period prior to participating in this study ( $p < 0.001$ ) (see Table 2). A higher proportion of children with possible undiagnosed asthma (79%) than diagnosed asthma (67%) identified with being of Mexican origin ( $p = 0.036$ ). Approximately 90% of both diagnosed and possible undiagnosed asthmatic students were covered by insurance and almost all children with diagnosed asthma (99%) reported having access to a doctor for routine medical care in the last year, compared to 91% of children with possible undiagnosed asthma ( $p = 0.002$ ). No statistically significant differences were found between children with diagnosed and possible undiagnosed asthma by age, gender, ethnicity, insurance coverage, or household smoking in the last year or those postponing care due to concerns about cost.

More than 93% of children with diagnosed asthma experienced  $\geq 1$  wheezing attack in the last year, compared to 79% of children with possible undiagnosed asthma ( $p = 0.001$ ); 51% of children with diagnosed asthma experienced sleep disturbance in the last year, compared to 35% of those with possible undiagnosed asthma ( $p = 0.005$ ). No statistically significant differences were found between children with diagnosed and possible undiagnosed asthma in terms of missed school days, speech limitations due to wheezing/asthma, or primary care use for wheezing/asthma in the last year.

Children with diagnosed asthma were more likely to report medication use during the previous year than were children with possible undiagnosed asthma ( $p = 0.001$ ). Indeed, 95% of children with diagnosed asthma reported use of medication for their symptoms in the last year, compared to 70% of those with possible undiagnosed asthma. The most frequent medications used by children with diagnosed asthma were preventative medications: long-acting bronchodilators with corticosteroids (advair or symbicort) (85%), corticosteroids (flovent, pulmicort, asmanex) (80%). Among students with possible undiagnosed asthma, the most frequent medications used were long-acting bronchodilators (38%), corticosteroid tablets/syrup (32%), short-acting bronchodilator/rescue inhaler/

**Table 2** Variables by asthma status

	<i>Undiagnosed asthma (n = 123)</i>	<i>Diagnosed asthma (n = 172)</i>	<i>p value<sup>a</sup></i>
<i>Age in years (mean ± SD)</i>	10.3 ± .8	10.4 ± .8	Prob <i>F</i> > 0.1153
<i>Gender, N (%)</i>			0.790
Girls	51 (42%)	69 (41%)	
Boys	70 (58%)	101 (59%)	
<i>Child's history of allergies, N (%)</i>			< 0.001*
Yes	84 (71%)	150 (89%)	
No	34 (29%)	18 (11%)	
<i>Child nativity, N (%)</i>			0.226
Foreign-born	8 (7%)	6 (4%)	
US-born	113 (93%)	164 (96%)	
<i>Ethnicity, N (%)</i>			0.384
Non-Hispanic	21 (18%)	37 (22%)	
Hispanic	99 (83%)	164 (78%)	
<i>Child is of Mexican origin, N (%)</i>			0.036*
Yes	92 (79%)	113 (67%)	
No	25 (21%)	55 (33%)	
<i>Survey language, N (%)</i>			0.324
Spanish	31 (25%)	35 (20%)	
English	92 (75%)	137 (80%)	
<i>Maternal education, N (%)</i>			0.908
Less than high school	6 (5%)	10 (6%)	
High school graduate	26 (21%)	34 (20%)	
College/technical school	66 (54%)	88 (51%)	
Graduate/professional	25 (20%)	40 (23%)	
<i>Maternal nativity, N (%)</i>			0.925
Foreign-born	40 (36%)	58 (36%)	
US-born	70 (64%)	104 (64%)	
<i>Smoking, N (%)</i>			0.687
Yes	9 (8%)	155 (91%)	
No	111 (92%)	15 (9%)	
<i>Insurance coverage, N (%)</i>			0.848
Yes	110 (89%)	155 (90%)	
No	13 (11%)	17 (10%)	
<i>Regular doctor in the last 12 months, N (%)</i>			0.002*
Yes	111 (91%)	168 (99%)	
No	11 (9%)	2 (1%)	
<i>Postponement of care due to costs</i>			0.128
Yes	46 (38%)	50 (29%)	
No	76 (62%)	121 (71%)	
<i>Burden of illness</i>			
Had ≥ 1 wheezing attack	96 (79%)	158 (93%)	0.001*
Had ≥ 1 missed school day	45 (45%)	93 (57%)	0.065
Had ≥ 1 sleep disturbance	42 (35%)	87 (51%)	0.005*
wheezing limited speech	11 (9%)	24 (14%)	0.192
<i>Health care service utilization</i>			
Primary care use for wheezing/asthma	55 (65%)	109 (73%)	0.249
<i>Medication utilization in the last year</i>			
Any medication use	68 (70%)	156 (95%)	< 0.001*
<i>Type of medication used for wheezing or asthma</i>			



**Table 2** (continued)

	Undiagnosed asthma (n = 123)	Diagnosed asthma (n = 172)	p value <sup>a</sup>
Corticosteroids	20%	80%	< 0.001*
Long-acting bronchodilators	37.5%	62.5%	0.726
Long-acting bronchodilators with corticosteroids	15%	85%	< 0.001*
Corticosteroid tablets/syrup	32%	68%	0.084
Short-acting bronchodilator/rescue inhaler/nebulizer	27%	73%	< 0.001*
Montelukast	22%	78%	< 0.001*

<sup>a</sup> Chi-square and Fisher’s exact tests for categorical variables and *t* tests for normally distributed continuous variables

\*Statistical significance at *p* < 0.05

nebulizer (27%), and corticosteroids (20%). Almost three-quarters of those with diagnosed asthma used rescue medications (short-acting bronchodilator/rescue inhaler/nebulizer) compared to 27% of children with undiagnosed asthma.

**Multivariate Results** Table 3 presents results of the model predicting ≥ 1 wheezing attack in the last 12 months. Controlling for the other variables, the odds of wheezing attacks were significantly greater among children with diagnosed asthma status, who had postponed care due to concerns about cost, who used primary care for wheezing/asthma, had insurance, had sleep disturbances, and had US-born mothers (*p* < 0.05). Table 4 depicts results for sleep disturbance. Missed school day(s) and the use of asthma medications were associated with significantly greater odds of this outcome (*p* < 0.05). Table 5 reports results when predicting any medication use in the last year. Odds were significantly higher among those with diagnosed asthma, children with ≥ 1 sleep disturbance, and those who accessed primary care for episodes of wheezing (*p* < 0.05). The odds of any medication used were lower among those who experienced exposure to household smoking in the last year (*p* < 0.05).

**Table 3** Logistic regression model predicting ≥ 1 wheezing attack in the last year (n = 186). Model fit: Pseudo R<sup>2</sup> = .26

	OR	SE	p value	95% CI
Intercept	0.01	0.01	< 0.01	(0.00–0.18)
Gender (male)	1.79	1.06	0.33	(0.56–5.70)
Asthma (diagnosed)	3.25	1.93	0.05*	(1.02–10.40)
Postponement of care due to cost	6.29	5.66	0.04*	(1.08–36.72)
Primary care use for wheezing/asthma	6.04	3.74	< 0.01*	(1.80–20.30)
Insurance coverage	43.12	48.07	< 0.01*	(4.85–383.48)
Had sleep disturbance	6.09	4.70	0.02*	(1.34–27.65)
Maternal nativity (US-born)	3.88	2.45	0.03*	(1.13–13.37)

\*Statistical significance at *p* < 0.05

## Discussion

A better understanding of the factors associated with asthma status among this rapidly growing US-México border population may help clinicians lessen the lifetime burden of disease by identifying children in need of an asthma diagnosis to prevent an exacerbation of symptoms to severe illness later in life. Historically, higher reporting of physician-diagnosed asthma among non-Mexican-American white children than Mexican-Americans (6.5% vs. 1.9%) has masked the burden of illness among the Mexican American population, even when rates of respiratory symptoms were equal between groups [31]. In this study of children with a history of wheezing/asthma symptoms in the previous year, 58% had physician-diagnosed asthma, whereas 42% met criteria for possible undiagnosed asthma. Slightly over half (51%) of children in this sample missed school due to their asthma symptoms, which is similar to the 58% observed by Neffen et al. [21]; however, we did not find statistically significant differences related to missed school days based on asthma status. This is in line with the work of van Gent and colleagues [7] who found comparability of asthma morbidity related to school absences between children with diagnosed and undiagnosed asthma. Comparing students of Mexican origin with non-Hispanic students and Hispanic students not of Mexican

**Table 4** Logistic regression model predicting sleep disturbance in the last year (n = 204). Model fit: Pseudo R<sup>2</sup> = .13

	OR	SE	p value	95% CI
Intercept	0.40	0.37	0.32	(0.07–2.40)
Gender (male)	0.81	0.26	0.51	(0.42–1.53)
Asthma (diagnosed)	1.51	0.53	0.24	(0.76–3.00)
Postponement of care due to cost	0.89	0.33	0.76	(0.44–1.83)
Medication use	3.74	2.33	0.03*	(1.10–12.68)
Survey language (English)	0.56	0.24	0.18	(0.24–1.30)
> 1 missed school day	3.89	1.26	< 0.01*	(2.06–7.33)
Insurance coverage	0.41	0.25	0.14	(0.13–1.32)

\*Statistical significance at *p* < 0.05

**Table 5** Logistic regression model predicting any medication use in the last year ( $n = 289$ ). Model fit: Pseudo  $R^2 = .35$ 

	OR	SE	<i>p</i> value	95% CI
Intercept	0.03	0.06	0.03	(0.00–0.77)
Gender (male)	1.21	0.71	0.75	(0.38–3.83)
Asthma (diagnosed)	5.89	3.71	0.01*	(1.71–20.25)
Insurance coverage	4.67	4.85	0.14	(0.61–35.76)
Child's history of allergies	2.84	1.97	0.13	(0.73–11.08)
Hispanic	2.49	1.70	0.18	(0.65–9.49)
Sleep disturbance	6.08	4.54	0.02*	(1.41–26.30)
Survey language (English)	4.49	5.34	0.21	(0.44–46.27)
Primary care use for wheezing/asthma	7.43	4.45	<0.01*	(2.30–24.05)
Maternal nativity, US-born	0.21	0.22	0.14	(0.03–1.68)
Smoking in home	0.15	0.13	0.03*	(0.03–.81)

\*Statistical significance at  $p < 0.05$

descent, the odds of diagnosed asthma were 44% lower and the odds of undiagnosed asthma were 79% higher among students of Mexican origin ( $p < 0.03$ ). These results are in line with those of Yeatts and colleagues, who found independent associations between being of Mexican-American background with undiagnosed wheezing (OR = 1.32; 95% CI, 1.17–1.48) [8]. However, unlike Yeatts and colleagues, who found comparable asthma morbidity among children with a history of wheezing, we found that children with possible undiagnosed asthma had lower odds of experiencing wheezing attacks (OR, 0.29; 95% CI, 0.14–0.61) and sleep disturbance (OR, 0.51; 95% CI, 0.31–0.82) compared to students with diagnosed asthma.

Our results suggest that the burden of illness among these children is high; however, possible undiagnosed (vs. physician-diagnosed) asthma status was not generally associated with worse outcomes, as might be expected. We found that students with an asthma diagnosis were more likely to report any medication use for wheezing/asthma and to experience a higher burden of illness in the last year compared to students with possible undiagnosed asthma. Whereas the former was anticipated, the latter was not. We expected that students with asthma-like symptoms without a diagnosis would be more likely to experience a higher burden of illness related to the frequency of wheezing attacks and sleep disturbance stemming from a lack of diagnosis and subsequently, a lack of ongoing symptom management/treatment. We also expected children with possible undiagnosed asthma to report not having access to a doctor for routine medical care, insurance, or treatment for episodes of wheezing/asthma, given prior scholarship describing the underuse of controller medication among children with Medicaid [32]. Instead, we found a high proportion of students with possible undiagnosed asthma reported having a doctor for routine medical care in the last year

(91%), insurance coverage (90%) and receiving treatment for episodes of wheezing/asthma (70%). Additionally, less than half of children with undiagnosed asthma (40%) and children with diagnosed asthma (30%) postponed or did not seek medical treatment due to concerns about cost ( $p = 0.128$ ). Our results show that students with asthma-like symptoms in this sample are not faring worse than children with asthma symptoms and a diagnosis. The former are being evaluated and receiving treatment for their symptoms; however, they are not receiving the diagnosis that would elicit a preventive rather than an ameliorative treatment strategy.

The American Academy of Family Physicians describes two major differences between asthma medications: those that control symptoms and those that prevent symptoms; inhaled corticosteroids, long-acting beta agonists (LABA), and leukotriene receptor antagonists are asthma medications used over time to control symptoms [33]. Compared to inhaled corticosteroids, which are the preferred first-line treatment for the control of symptoms, short-acting and oral corticosteroids are used as needed to manage acute episodes [34] while a Montelukast (Singulair) is used for mild and/or exercise induced asthma [35]. In this sample, students with possible undiagnosed asthma reported using medications to treat acute symptoms, while students with diagnosed asthma reported using medications to prevent the worsening of symptoms. Use of long-term controller medications confer protection against exacerbation of asthma leading to hospitalizations [36, 37], whereas inconsistent use of acute medications may lead to scarring and airway remodeling that could permanently damage children's lungs [38–40].

Our findings raise concern about the possibility of lower quality care among the undiagnosed given their receipt of acute medications without a diagnosis. Our presumption of lower quality care among the undiagnosed is based partly on the fact that they are more likely to receive ameliorative rather than preventive treatment compared to the diagnosed. The use of prescription medication to treat acute symptoms suggests that children with possible undiagnosed asthma may not be receiving adequate care despite having insurance and access to care. It is plausible that they remain undiagnosed because of poor quality care rather than a lack of access to care, but more research is needed to confirm this. These findings are congruent with other evidence showing that those with undiagnosed asthma do not experience a greater burden of illness or use healthcare services more frequently than diagnosed children, and that even after adjustments for access-related factors, Hispanics receive lower quality healthcare than whites [41–43].

The current study has a number of strengths. This is the first study to assess the burden of possible undiagnosed asthma among elementary school children along the US-México border region of El Paso, Texas. Using a validated instrument employed throughout the world ensures that one is measuring what one intends to measure accurately; it also allows for

comparability to other studies. This study also has limitations. Notably, data come from primary caretaker self-report sent to households by mail, to which 30% of respondents replied. While it is possible that household surveys with similar response rates may represent the target population [44], we also recognize that the complexity of the study instrument and skip-patterns may have dissuaded participants with low-literacy skills to respond—whether at all or accurately. Although self-reporting, whether directly or by proxy, is common, it is possible that respondents with children expressing less severe symptoms or those with low health literacy may not have been familiar with the description of symptoms and/or medications/treatments listed as response options, leading to underreporting of both. Prior scholarship on wheezing and asthma in South Texas describes a lower reporting of wheezing and/or asthma by Mexican-American parents with less than a high school level of education, compared to other racial/ethnic groups with less than a high school level of education [45]. In this study, the majority of respondents reported a college/technical level of maternal education and we did not find differences in asthma status by maternal level of education.

Some describe that children who experience respiratory distress are more likely to suffer from a higher burden of illness throughout their lifetime than children who do not experience respiratory distress [8]. In most cases, the burden of illness associated with wheezing/asthma symptoms can be managed with proper treatment; however, obtaining the proper treatment requires that the symptoms be severe enough to warrant medical attention. While physician diagnosis of asthma facilitates its treatment, management, and may limit the worsening of symptoms throughout the lifespan, among underserved communities like those along the US-Mexico border region, an underdiagnosis of symptoms may result in delayed treatment, an exacerbation of symptoms to severe illness, and/or an increase in medical expenses as these children mature into adulthood. Our results, specifically that children with asthma-like symptoms are insured and receiving the treatment they need, are encouraging overall. However, we recognize that access to care, as measured by health insurance status in this analysis, is more scarce now than in 2012, when this study was conducted. Whereas the percent of children in Texas without health insurance decreased from a high of 17.6% in 2008 to a low of 9.8% in 2016, this trend is now reversing [46].

Additional studies examining the medication utilization patterns of children with possible undiagnosed asthma would be an asset to the current literature. While the long-term effects of differential treatment based on diagnosis status could not be assessed in the present study, we hypothesize that the burden of illness will increase among undiagnosed individuals to a greater degree (relative to diagnosed ones) as they move into adulthood. That is a question to be addressed through future

study. This information could provide a better understanding of needs and inform community-specific preventive programs to address the signs and symptoms of uncontrolled wheezing and asthma.

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## Compliance with Ethical Standards

The Institutional Review Board (IRB) at the University of Texas at El Paso (UTEP), and then the University of Texas, School of Public Health (UTSPH) reviewed and approved the protocol for this study. Informed consent was obtained from all participants

**Conflict of Interest** The authors declare that they have no conflict of interest.

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