Social Determinants of Asthma in American Indian Children

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Abstract

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Background

American Indian (AI) / Alaska Native (AN) children have a higher asthma prevalence than white children in the U.S. (9.4% versus 7.7%, respectively). The AI/AN population is extremely diverse; demographic, lifestyle, genetic, and environmental factors influence asthma prevalence and severity in these communities. Our study sought to examine risk factors associated with asthma among children in an American Indian community, and to describe risk factors and differences in clinical course between asthmatic cases on a controller medication versus those not on a controller.

Methods

This is a case-control study of children with physician-diagnosed asthma and age-matched controls, ages 6 through 17 years, in an American Indian community. Diagnosis and

clinical characteristics were obtained from medical record review. Home study visits included interviews, asthma control and quality of life questionnaires, and physical exam.

Results

Among the 108 asthmatic cases and 215 controls, 64% had an annual household income <$25,000, of which 39% were <$10,000. Lower annual household income level (p=0.04), type of housing (multi-unit dwelling versus single-occupancy residence, p=0.04), and home infestation of rodents or insects (p=0.01) were positively associated with asthma. Children with asthma had significantly higher odds of atopy, food allergies, and history of RSV infection than controls. A large proportion of both cases and controls reported persistent respiratory symptoms, though the prevalence was significantly higher among cases: cough (48 vs 14%, OR 19.0, 95%CI: 9.1-41.4), wheeze (53 vs 5%, OR 5.6, 95%CI: 3.2-10.1), and dyspnea (49 vs 6%, OR 14.2, 95%C: 6.9-30.2).

Conclusion

In this low-income AI community, we identified several social determinants of asthma, including lower income and suboptimal housing conditions. Many children with asthma reported persistent cough, wheeze, and dyspnea, indicators of poorly controlled asthma. The prevalence of chronic respiratory symptoms reported by controls merits further investigation to identify and potentially treat unrecognized lung disease in AI children.

INTRODUCTION

Asthma is a common chronic disease affecting > 25 million adults and children in the United States.[1] In the 2001-2005 National Health Interview Survey, the prevalence of asthma in American Indians (AI) and Alaska Native (AN) children ages 2-17 years was 13.0%, compared to 8.4% in non-Hispanic white children of the same age.[2] In a recent study measuring prevalence of asthma in children from 2001-2010, AI/AN consistently had a higher asthma prevalence than non-Hispanic white children (9.4% versus 7.7%, respectively).[1] Further, the morbidity associated with asthma, including hospitalizations and poor clinical outcomes, is greater among Indigenous children compared with their non-Indigenous counterparts in Australia, Canada, New Zealand and the US.[3] Individual, family, and community-level factors are associated with asthma incidence, prevalence and severity (**Figure 1**).[1] For instance, low socioeconomic status (SES) and poor living conditions are associated with an increased prevalence and severity of asthma.[4]

AI/AN people have lower household incomes and higher poverty rates than the general US population.[5] Our study population is a rural American Indian community located in the north-central portion of South Dakota with a high level of poverty (>25% of families below the federal poverty guidelines). The goal of the “Factors Influencing Pediatric Asthma (FIPA)” study is to better understand genetic and environmental risk factors for asthma in AI children who reside in this AI community. This analysis examines socio-economic and household environmental factors associated with pediatric asthma and describes asthma severity and risk factors for asthma severity among children enrolled in the FIPA study. We hypothesize that social determinants of health, including income level and lack of home ownership, are associated with higher risk of pediatric asthma. Furthermore, we hypothesize that environmental exposures, such as smoke exposure and early childhood respiratory infections, are associated with risk of asthma.

METHODS

Study Design & Population

This is a case-control study derived from the FIPA study focused on environmental and genetic influences on pediatric asthma in an AI community in the north-central United States.[6] This American Indian community is in the north-central portion of South Dakota in an area covering 4266 square miles. The population is about 8500, with approximately 2500 between the ages of 5-18 years, resulting in a population density of between 2 and 3 people per square mile. Farming and ranching provide the bulk of employment; however, the counties that comprise the community are the 11th and 4th lowest per capita income counties in America, and 33 and 42% of residents in the two counties have incomes below the federal poverty line.

Ascertainment of Cases and Controls

Cases and controls were ascertained as previously described.[6] Briefly, potential cases were identified using the Indian Health Service (IHS) electronic medical records systems using search queries including asthma-specific ICD-9 codes between 493.00 and 493.92, 786.07 (wheezing) and V17.5 (family history of asthma) (**Figure 2**). Cases comprised American Indian children ages 6 through 17 years receiving care through the Indian Health Services (IHS) with at least 2 of the following 3 criteria: 1) diagnosis of asthma on at least 2 occasions by more than one provider during the past 2 years; 2) receiving refills of asthma treatment medications on at least 2 occasions during the past 2 years; and 3) improvement of forced expiratory volume at one second (FEV_1) of 20% with use of albuterol metered dose inhaler (MDI) or nebulizer. All cases enrolled in the study met the first two inclusion criteria; none met inclusion criterion 3.

Exclusion criteria included birthweight less than 2500 grams, history of neonatal ventilator treatment, hospitalization at birth greater than 15 days, congenital heart defect requiring surgery, cystic fibrosis, congenital lung, diaphragm, chest wall or airway anomaly, or congenital muscular disorder (**Figure 2**). Children were also excluded if they had a diagnosis of pneumonia, pertussis, or tuberculosis within the past year.

Controls were identified by query of the IHS electronic database in the same community. Each control was aged-matched to a case (i.e., birthdate within 6 months of the previously identified asthma cases). Controls did not have a diagnosis of asthma by a provider during the past 2 years, had no prescriptions of asthma medications in the past two years, or FEV_1 less than 80% of predicted value if prior spirometry was performed, but otherwise met the same exclusion criteria as cases.

Medical Record Review

Information pertaining to the diagnosis and management of asthma was abstracted from medical records. These results included birth date, history of tobacco use or exposure to smoke, comorbid conditions, pulmonary function testing, chest x-ray reports, and medications. To ensure chart review accuracy, the first five charts extracted by a new researcher and every 10^{th} subsequent chart abstraction were reviewed by a second, experienced reviewer.

Baseline Interview and Examination

A one-time home visit for cases and controls was performed by study staff. A structured interview collected information on demographics, educational attainment, current parental occupation, current location of residence, information regarding lifestyle factors, environmental exposures in the home, and current medication use. The Asthma Control Test (ACT, Asthma Control Test™ of QualityMetric Incorporated ©2017 GKS) was used to assess adequacy of asthma control for asthmatic cases, with ACT scores >20 indicating well-controlled asthma. The American College of Allergy, Asthma, and Immunology Asthma Life Quality (ALQ) Test was given to both asthmatic cases and their parents/guardians. The ALQ is a 20-question validated questionnaire designed to help identify patients with asthma and to differentiate those more likely to have moderate/severe asthma, where a higher ALQ score correlates with a higher likelihood of moderate or severe asthma.[7] An Asthma Knowledge (AK) test was administered to all asthmatic cases ages 10-17 year or to a caregiver if the child was ages 6-9 years, and maximum score is 12.

Statistical Analysis

Pearson's chi-square test for categorical variables: age, gender (male/female), caregiver marital status (never married, previously married, married, significant other/partner/roommate), caregiver educational level (less than high school, high school graduate, graduate/professional school), annual household income (<$25,000, $25,000-50,000, >$50,000), insurance program, private insurance (yes/no), unemployed caregiver (yes/no), home ownership (yes/no), home type (single, duplex/4-plex, apartment, trailer/FEMA trailer), occupants in home, water damage in home (yes/no), heating source (wood-burning stove, yes/no), carpet in home (yes/no), pets in home (yes/no), tobacco exposure (yes/no), were used to assess the association of individual, socioeconomic and home environmental factors with asthma. Home type (single occupancy residence versus multi-unit dwelling) and home infestation (yes/no) were collapsed into binary variables and Mantel-Haenszel odds ratios (ORs) were generated to evaluate the relationship between these characteristics and asthma. To assess asthma symptoms and asthma control, asthmatic children were stratified based on use of a controller medication (inhaled corticosteroid and/or montelukast), and the above statistical analysis was repeated using Pearson's chi-square test for categorical variables (listed above). Wilcoxon-Mann-Whitney test for continuous variables was utilized to compare ACT, ALQ and AK scores among cases. Mantel-Haenszel odds ratios were generated to evaluate the relationship of clinical factors (cough in past 4 weeks, wheeze in past 4 weeks, dyspnea in past 4 weeks, history of prematurity, atopy, history of RSV infection, parental report of respiratory hospitalization, lifetime history of ED visit, and lifetime history of hospitalization) with (1) asthma; and, (2) controller use among children with asthma. Statistical significance was set at $\rho < 0.05$. STATA^{R} 14.2 statistical software was utilized to conduct the univariate statistical analysis.

Approval

This study was approved by the following IRB and ethics committees: Sanford Research/USD Department of Health Outcomes and Prevention Research Institutional Review Board, and the Tribal government. Informed consent was obtained from parents/guardians, and assent from participants as applicable.

RESULTS

Patient Demographics & Clinical Characteristics

Between 2012-2014, 108 asthma cases and 215 age-matched controls enrolled in the study (**Table 1**). Median age of cases was 11 years (range 6-17 years), and of controls was 12 years (range 6-17 years). Males comprised 51.9% and 51.2% of asthmatics and controls, respectively.

Nearly 64% of all children had a household annual income less than $25,000, and 39% reported an annual income < $10,000. Lower annual household income level was associated with asthma ($p = 0.04$). Children with asthma were less likely to live in overcrowded households (≥ 4 individuals in household) compared to controls (57.0% versus 76.8%, respectively, $p < 0.001$). There was no significant difference between cases and controls regarding other SES factors of interest, including caregiver education level and health insurance status.

Over 60% of caregivers of children with asthma believed that their home environment was worsening their child's health, compared to 17% of caregivers of controls ($p < 0.001$). Children with asthma had significantly higher odds of living in a multi-unit dwelling (apartment, 4-plex, or duplex) versus a single-occupancy residence (single-family home, trailer) compared to non-asthmatics (OR 2.29, 95% CI: 1.19-4.38, **Supplemental Table 1**). Children with asthma were more likely to live in residences with parent-reported rodent or insect infestation compared to non-asthmatic children (OR 2.09, 95%CI: 1.14-3.84). There was no significant difference in heating source, or smoke exposure between asthmatic cases and controls.

Children with asthma had significantly higher odds of atopy (history of hay fever and/or seasonal allergies), food allergies, history of RSV infection, and history of lung infection than controls (**Table 2**). Persistent cough (48%), persistent wheeze (56%), and dyspnea (52%) were reported frequently in the asthmatic cases. A considerable proportion of controls also reported history of atopy (23%) and persistent cough (14%). Children with asthma had a higher odds of lifetime ED visit (OR 2.6, 95% CI: 1.42-4.56) and parental report of respiratory hospitalization (OR 4.4, 95%CI: 2.32-8.43); however, there was no difference between asthma cases and controls in the odds of lifetime hospitalization as recorded by the Indian Health Service.

Mean (SD) asthma control (ACT) score for asthmatic children ages 5-11 years was 19.7 (4.1), and 18.1 (5.1) for children ages 12-17 years, where ACT scores >20 indicate well-controlled asthma. Mean (SD) child-reported asthma life quality (ALQ) score was 11.5 (6.3), and mean parent-reported ALQ scores was 9.6 (4.7), where a higher ALQ score correlates with a higher likelihood of moderate/severe asthma. Mean (SD) asthma knowledge (AK) was 8.8 (1.7), with a maximum score of 12.

Asthma Cases: Asthma Controller Status

Among asthmatic children, 52.8% reported current bronchodilator use, 13.0% reported inhaled corticosteroid use, 17.6% were on an allergy medication, and 19.4% were on a leukotriene inhibitor. Caregiver educational level varied between asthmatic children on a controller medication (inhaled corticosteroid and/or montelukast, n=26) compared to asthmatic children not on a controller (n=82, p =0.03), with 30.8% of caregivers of children receiving controller therapy graduating from high school, compared to 60.0% of caregivers of children not receiving controller therapy. However, 42.6% of caregivers of children receiving controller therapy reported graduate/professional school, compared to 22.5% of caregivers of children not receiving controller therapy. Children with asthma on a controller medication were more likely to live in a home with a history of water damage (OR 2.95, 95%CI: 0.97-8.65) and carpet (OR 2.74, 95%CI: 1.00-7.83), compared to asthmatic children not on a controller (**Supplemental Table 2**). Children with asthma on controller medication had increased odds of parental report of prematurity (OR 5.87, 95% CI: 1.63-21.20) (**Table 3**) compared to asthmatic children not on a controller. Cases on a controller had higher, yet not statistically significant, child-reported asthma life quality (ALQ) questionnaire scores (13.5 versus 10.8, p-value=0.57), compared to asthmatic children not on a controller medication, indicating a higher likelihood of moderate-severe asthma and/or suboptimal asthma control (**Supplemental Table 3**). Mean ACT scores of asthmatic children did not vary based on controller status. Nine asthmatic children reported non-compliance with asthma medications due to either believing the medication wasn't needed, perceived side effects, or other concerns.

DISCUSSION

In this generally low-income AI community, asthma was more common in children in the families who reported the lowest incomes, those that resided in multi-unit housing, and those experiencing poor living conditions, including residential insect and/or rodent infestations. Other social determinants of health, including caregiver education level and health insurance, were not associated with asthma, while household overcrowding was more common among children without asthma.

This AI community is located in two counties within the top twenty-five poorest per capita income counties in the United States. Lower income level and poor living conditions have been associated with increased prevalence and severity of asthma, and contribute to inadequate health care utilization and lack of asthma awareness and education. In published studies, approximately 11.2% of individuals with incomes less than 100% of the poverty level have asthma, compared to 8.5% of individuals with incomes 100% to 200% of the poverty level, and 7.3% for individuals with incomes at least 200% of the poverty level.[1,4] In a study of 33,201 households of asthmatic children ages 6-17 years, Hughes *et al.* demonstrated that poor housing quality was associated with asthma diagnosis and ED visits, and home ownership was associated with a lower odds of asthma-related ED visits.[8]

In a study of Yup'ik children in southwestern Alaska, crowded housing conditions, low income levels, and frequent exposure to environmental tobacco and wood-burning stove emissions predisposed children to asthma.[5] Use of indoor wood-burning stoves among AI/AN people has been linked to poor indoor air quality and higher rates of lower respiratory tract infections (LRTI) and is possibly related to increased asthma prevalence and hospitalization.[9] In our study, the prevalence of wood-burning stoves was low for both asthmatic children (4.6%) and controls (2.8%). However, there was significant tobacco exposure in both cases and controls (72.4% and 66.3%, respectively). As the leading and most preventable irritant for asthma, environmental tobacco smoke exposure should be the focus of further community education and intervention programs.

Children with asthma were more likely to have a history of RSV infection, lifetime emergency department visits, and parental report of respiratory hospitalizations. AI/AN children are known to have higher morbidity and mortality from acute respiratory illnesses (ARIs), including respiratory syncytial virus (RSV), and the death rate from ARI among AI/AN children is twice that of infants in the general U.S. population (0.4 death/1000 versus 0.2 deaths/1000, respectively).[10,11] AN children have increased rates of RSV infection, and a 3-fold increase in rate of RSV hospitalization compared to the general U.S. population.[12] The Canadian Inuit population has the highest rate of RSV hospitalization in the world (166 per 1000 infants).[13,14] Given the association of RSV infection in early infancy and recurrent wheezing and childhood asthma,[15,16] increased incidence of early childhood RSV infection may be an important contributor to increased asthma prevalence among AI/AN populations.

Many children with asthma reported persistent cough, wheeze, and dyspnea, possibly indicating poorly controlled asthma, yet only 24% cases reported using a controller medication (inhaled corticosteroid and/or montelukast). In a study among Navajo American Indians with asthma, many participants stopped taking their medications once symptoms improved, and many discontinued medication for asthma as they believe that asthma will disappear "on its own if the body is allowed to heal itself.".[17] This same study found that 80% of AI children had assumed responsibility for taking their own medication, leading to increasing rates of inadequate utilization and low compliance.[17]

A substantial proportion of controls reported persistent respiratory symptoms, raising concern for either unrecognized lung disease, or possible environmental exposure to airway irritants, such as smoke exposure. The Indian Health Service, the federal agency that provides health care for Indian people, is often unable to provide specialty treatment for more challenging cases of asthma due to lack of funds, time, or resources. The overall low SES of this AI community may limit access to alternative sources of healthcare and therefore asthma diagnosis and treatment may be constrained at times.

This study has several limitations. First, selection bias may have occurred, as children and families who participated in the study may be different than those who chose not to participate, and thus, generalizability of the findings may be limited. Second, interviewer bias may have occurred, as different research team members collected data, and interview questions were no standardized. Another limitation is the potential for recall bias, as questionnaires were used to collect past medical history from patients and families. Furthermore, recall bias may be differential, as cases or caregivers of cases may report differently than those without an established asthma diagnosis.

CONCLUSION

Asthma is a prevalent health concern in AI communities. In our study, social determinants of health, including lower household income and rodent infestations, were associated with asthma prevalence and severity. The persistent respiratory symptoms in controls provides insight into the need for better characterization of prevalence of asthma or other lung diseases among American Indians. Furthermore, asthmatic cases had a high prevalence of respiratory symptoms, causing concern for inadequately controlled asthma in the community. An additional aim of the FIPA study involved a randomized-controlled trial examining implementation of an intensive asthma education program, emphasizing patient-centered, self-management of asthma, and assessing emergency department utilization. The results of this study and other intervention strategies in Native communities will hopefully determine more effective means and levels of intervention.

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Figure 1. Conceptual map describing potential socioeconomic (SES) factors associated with pediatric asthma previously described[1,2,4,8,9,16-18]
*Factors evaluated in this American Indian pediatric population

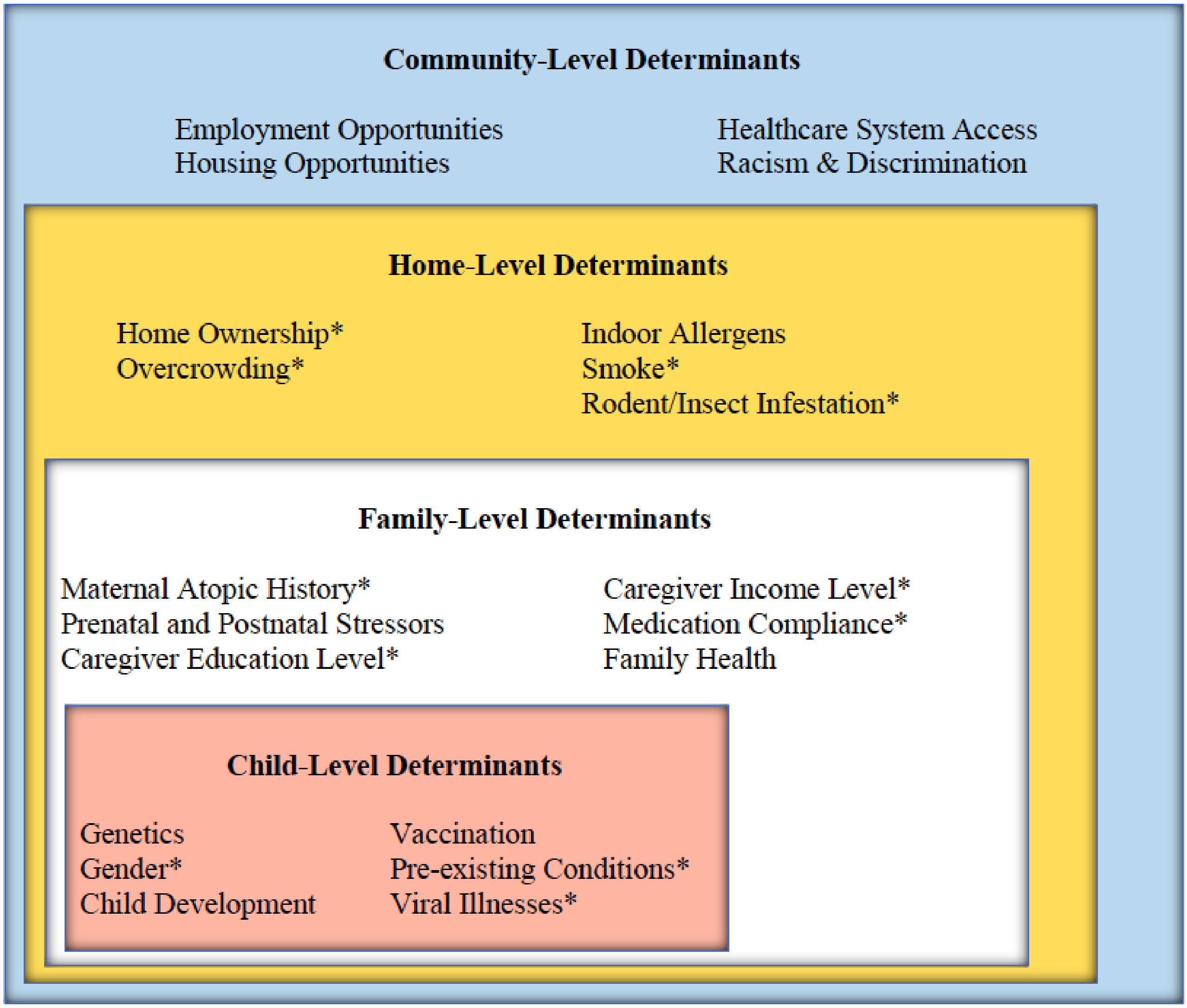

Figure 2. Flow diagram of case and control ascertainment

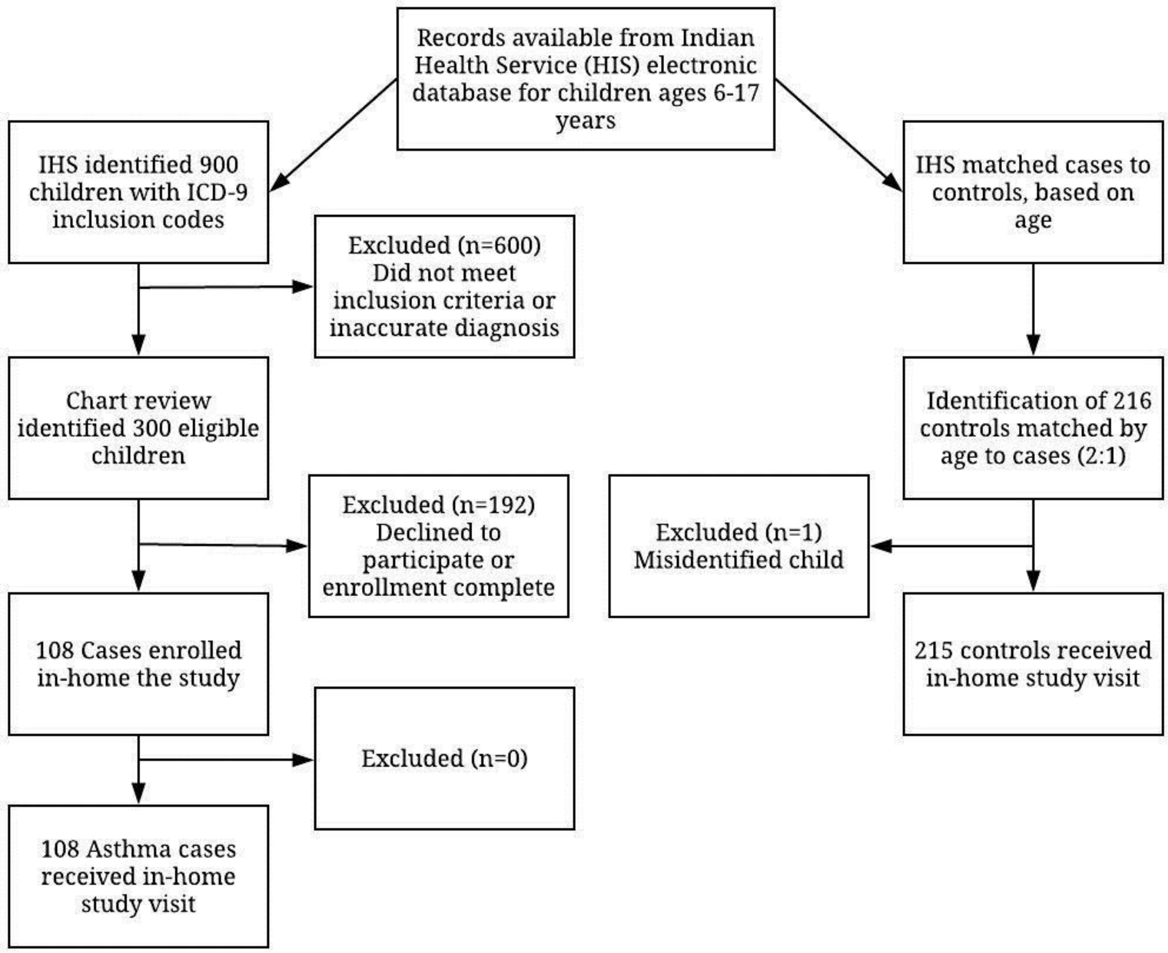

Table 1. Characteristics of American Indian Children, Ages 6-17 years, Stratified by Asthma Cases and Controls

	Asthma Cases (N=108)*		**Controls (N=215)***		
	N	**%**	**N**	**%**	**p-value†**
Age (Mean, Std)	11.31 (3.02)	N/A	11.62 (3.25)	N/A	0.80
Male Gender	56	51.9	110	51.2	0.91
Caregiver Marital Status					0.21
Never Married	36	34.0	51	24.1	
Married	31	29.3	83	39.2	
Previously Married	26	24.5	50	23.6	
Significant Other/Partner/Roommate	13	12.3	28	13.2	
Caregiver Education Level					0.12
Less than High School Education	20	18.9	23	11.0	
Completed High School	56	52.8	130	61.9	
Graduate/Professional School	30	28.3	57	27.1	
Annual Household Income					**0.04**
Less than $25,000	76	72.4	130	63.4	
$25,000-$50,000	24	22.9	46	22.4	
Greater than $50,000	5	4.8	29	14.2	
Government Insurance Programs	86	79.6	163	75.8	0.44
Private Health Insurance	10	9.7	25	12.3	0.50
Uemployed Adult in Home	28	26	45	21	0.31
Home Ownership	33	31	73	35	0.48
Home Type					**0.04**
Single	59	54.6	141	65.6	
Duplex/4-Plex	13	12.0	16	7.4	
Apartment	13	12.0	10	4.7	
Trailer/FEMA Trailer	18	16.7	35	16.3	
Occupants in Home					**0.00**
< =4 occupants	46	43.0	48	23.2	
5-8 occupants	44	41.1	108	52.2	
8-13 occupants	17	15.9	51	24.6	
Water Damage/Flood in Home	24	22.6	48	22.9	0.97
Heating Source in the Home					
Wood Burning Stove	5	4.6	6	2.8	0.39
Home Problems					
Mold or Water Leaks	34	31.5	81	37.7	0.56
Rodents or Insects	29	26.9	32	14.9	**0.01**
Carpet in Home	50	46.7	77	36.7	0.08
Pets in Home	74	68.8	154	73.7	0.47
Tobacco Smoke Exposure‡	76	72.4	136	66.3	0.28
Home Environment Worsening Child Health	63	60.0	35	17.0	**0.00**

*Numbers may not add up to totals because of missing data; percentages represent proportion of non-missing data for a given variable

†Statistical analysis included Pearson chi-squared test for categorical variables, and two-sample t-test for continuous variables. Significance level $p < 0.05$

‡ Tobacco smoke exposure in the home, outside home, and/or car

Table 2. Clinical Characteristics of American Indian Children, Ages 6-17 Years, Stratified by Asthma Cases and Controls

	Asthma Cases (N=108)		**Controls (N=215)**			
	n	**%**	**n**	**%**	**OR**	**95 % CI**
Clinical Characteristics[b]						
History of Prematurity	16	15.2	20	9.5	1.72	(0.79, 3.67)
Atopy Diagnosis	56	54.9	49	23.2	**4.02**	**(2.36, 6.87)**
Food Allergy Diagnosis	18	16.8	7	3.3	**5.89**	**(2.23, 17.20)**
History of RSV Infection	37	35.2	33	15.7	**2.91**	**(1.63, 5.22)**
History of Lung Infection[c]	67	65.1	50	24.2	**5.84**	**(3.38, 10.12)**
Persistent Cough in Past 4 Weeks	51	48.1	30	14.2	**18.95**	**(9.08, 41.44)**
Persistent Wheeze in the Past 4 Weeks	56	53.3	12	5.7	**5.63**	**(3.16, 10.05)**
Dyspnea in the Past 4 Weeks	52	49.1	13	6.4	**14.15**	**(6.91, 30.18)**
Parental Report of Respiratory Hospitalization	35	31.5	22	10.2	**4.40**	**(2.32, 8.43)**
Family History of Asthma	50	48.5	69	33.2	**1.90**	**(6.91, 30.18)**
Maternal History of Asthma	12	11.1	18	8.4	1.35	(0.57, 3.11)
Behind in Class Due to Health	14	14.0	5	2.5	**6.48**	**(2.11, 23.56)**
Lifetime History of ED Visit[d]	35	32.4	34	15.8	**2.6**	**(1.42, 4.56)**
Lifetime History of Hospitalization[d]	8	7.4	7	3.3	2.4	(0.73, 7.91)

Abbreviations: RSV=Respiratory Syncytial Virus, PCP=Primary Care Provider, ED=Emergency Department

[a]Statistical analysis using Mantel-Haenszel odds ratios (OR). Significance level $p < 0.05$.

[b]Parental or self-reported medical history

[c]History of pneumonia, bronchitis, or other lung infection

[d]Lifetime history of ED visits or hospitalizations according to Indian Health Services medical records

Table 3. Clinical Characteristics of American Indian Children Comparing Asthmatics on a Controller Versus Not on a Controller, Ages 6-17 Years

	Asthmatics Controller[a] (N=26)		**Asthmatics No Controller (N=82)**			
	N	**%**	**n**	**%**	**OR[b]**	**95 % CI**
Clinical Characteristics[c]						
Cough in the Past 4 Weeks	12	46.2	39	48.8	0.90	(0.34, 2.40)
Wheeze in the Past 4 Weeks	13	50.0	43	54.4	0.84	(0.31, 2.24)
Dyspnea in the Past 4 Weeks	14	53.9	38	47.5	1.29	(0.48, 3.47)
History of Prematurity	9	36.0	7	8.8	**5.87**	**(1.63, 21.20)**
Atopy Diagnosis	15	60.0	41	53.3	1.31	(0.48, 3.71)
History of RSV Infection	11	42.3	26	32.9	1.49	(0.54, 4.05)
History of Lung Infection[d]	19	73.1	48	62.3	1.64	(0.57, 5.18)
Parental Report of Respiratory Hospitalization	10	38.5	25	32.1	1.33	(0.47, 3.63)
Lifetime History of ED Visit[e]	8	30.8	27	32.9	0.91	(0.30, 2.54)
Lifetime History of Hospitalization[e]	3	11.5	5	6.1	2.0	(0.29, 11.17)

Abbreviations: RSV=Respiratory Syncytial Virus, PCP=Primary Care Provider, ED=Emergency Department

[a]Controller defined as inhaled corticosteroid and/or montelukast

[b]Statistical analysis using Mantel-Haenszel odds ratios (OR). Significance level $p < 0.05$

[c]Parental or self-reported medical history

[d]History of pneumonia, bronchitis, or other lung infection

[e]Lifetime history of ED visits or hospitalizations according to Indian Health Services medical records

Supplemental Table 1. Household Factors and Asthma Case and Control Status in American Indian Children, Ages 6-17 years

	Asthma Cases (N=108)*		Controls (N=215)*			
	N	**%**	**N**	**%**	**OR**	**95% CI**
Home Type						
Multi-unit Dwelling (Apartment, 4-plex, Duplex)	26	25.2	26	12.9	**2.29**	**(1.19-4.38)**
Single Occupancy Residence	77	74.8	176	87.1	1.00	
Infestation						
Rodent or Insect Infestation	29	26.9	32	14.9	**2.10**	**(1.14-3.84)**
No Rodent or Insect Infestation	79	73.1	183	85.1	1.00	

*Numbers may not add up to totals because of missing data; percentages represent proportion of non-missing data for a given variable.

[b]Statistical analysis using Mantel-Haenszel odds ratios (OR). Significance level $p < 0.05$

Supplemental Table 2. Characteristics of American Indian Children Comparing Asthmatics on a Controller Versus Not on a Controller, Ages 6-17 Years

	Asthmatics Controller[a] (N=26)		Asthmatics No Controller (N=82)		
	N	**%**	**n**	**%**	**p-value†**
Caregiver Marital Status					0.77
Never Married	8	30.8	28	35.0	
Married	9	34.6	22	27.5	
Previously Married	5	19.4	21	26.3	
Significant Other/Partner/Roommate	4	15.4	9	11.3	
Caregiver Education Level					**0.03**
Less than High School Education	6	23.1	14	17.5	
Completed High School	8	30.8	48	60.0	
Graduate/Professional School	12	46.2	18	22.5	
Annual Household Income					0.90
Less than $25,000	18	69.2	58	70.7	
$25,000-$50,000	2	7.7	8	9.8	
Greater than $50,000	6	23.1	16	19.5	
Government Insurance Programs					
Private Health Insurance	2	8.7	8	10.0	0.85
Uemployed Adult in Home	8	31	20	24	0.52
Home Ownership	11	42	22	28	0.16
Home Type					0.83
Single	16	61.5	43	55.8	
Duplex/4-Plex	3	11.5	10	13.0	
Apartment	2	7.7	11	14.3	
Trailer/FEMA Trailer	5	19.2	13	16.9	
Occupants in Home					0.08
< =4 occupants	16	61.5	30	37.0	
5-8 occupants	8	30.8	36	44.4	
8-13 occupants	2	7.7	15	18.5	
Water Damage/Flood in Home	10	38.5	14	17.5	**0.03**
Home Problems					
Mold or Water Leaks	13	50.0	36	43.9	0.59
Rodents or Insects	6	23.1	23	28.1	0.62
Carpet in Home	17	65.4	9	34.6	**0.03**
Pets in Home	20	76.9	54	67.5	0.36
Tobacco Smoke Exposure‡	8	30.8	21	26.6	0.68

*Numbers may not add up to totals because of missing data; percentages represent proportion of non-missing data for a given variable

†Statistical analysis included Pearson chi-squared test for categorical variables. Significance level $p < 0.05$

‡ Tobacco smoke exposure in the home, outside home, and/or car

Supplemental Table 3. Clinical Characteristics of American Indian Children Comparing Asthmatics on a Controller Versus Not on a Controller, Ages 6-17 Years

	Asthmatics Controller[a] (N=26)		**Asthmatics No Controller (N=82)**		
	N	**Mean Score (95% CI)**	**N**	**Mean Score (95% CI)**	p-value[b]
Asthma Control Test (ACT)					
Ages 5-11 years[c]	17	19.3 (18.4, 21.4)	34	19.8 (18.4, 21.4)	0.64
Ages 12-17[d]	9	16.1 (9.9, 22.3)	43	18.5 (17.2, 19.8)	0.59
Asthma Life Quality (ALQ)[e]					
Parent Questionnaire	26	10.5 (8.7, 12.3)	68	9.2 (4.7, 8.1)	0.24
Child Questionnaire	26	13.5 (11.4, 15.7)	72	10.8 (9.2, 12.3)	0.06
Asthma Knowledge[f]	26	9.3 (8.56, 9.98)	77	8.8 (8.5, 9.2)	0.27

Abbreviations: RSV=Respiratory Syncytial Virus, PCP=Primary Care Provider, ED=Emergency Department

[a]Controller defined as inhaled corticosteroid and/or montelukast

[b]Statistical analysis using Wilcoxan-Mann-Whitney non-parametric test. Significance level $p < 0.05$.

[c]ACT maximum score=27, scores >=20 asthma well controlled, scores <20 asthma not well controlled

[d]ACT maximum score=25, scores >=20 asthma well controlled, scores <20 asthma not well controlled

[e]Asthma Life Quality (ALQ) maximum score=20

[f]Asthma knowledge maximum score=12