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The housing environment and its effect on Hispanic children with asthma

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Abstract

Introduction Substandard housing in Hispanic minority communities has been associated with detrimental effects on children with asthma that is affected by diverse indoor triggers. Identifying those triggers and offering adequate medical treatment and ways to prevent exposure to triggers will help reduce the number of asthma attacks among children who reside in Hispanic minority communities.

Objective Our study aimed to identify the influence of substandard housing quality and its effect on asthma symptoms. Our objectives included assessing the impact of building, flooring types, heating sources, window shading, parental smoking behaviors, moisture and mold in the home, ventilation, and owning a pet on asthma symptom occurrence.

Materials and methods Our study was based on a cross-sectional analytical study involving 353 individuals, their parents, and their homes. Logistic regression modeling was conducted to explain the dependence of each asthma symptom on the investigated independent variables, with child age and sex being investigated as covariables. A post hoc test was employed to ensure goodness of fit, and a pseudo-R square was calculated for each regression model. The Hosmer-Lemeshow test was performed post hoc to ensure goodness of fit, and models were preserved if $p > 0.05$.

Results The overall prevalence of asthma-related symptoms in our study sample was 19.37%, and sleeping quality was affected due to asthma in 23% of participating children. We also found that children living with asthma near agricultural fields were more prone to asthma-related symptoms, as well as those children living in homes with excessive moisture and those who kept stuffed toys or pets inside their rooms.

Conclusions Our study highlights how a variety of environmental factors, such as living near an agricultural area and having curtains, increases shortness of breath. Having leaks and excessive moisture in houses increases shortness of breath, wheezing, coughing, and rates of colds. Another important exposure is having a pet inside the house which increases chest tightness. A comprehensive understanding of these factors and how they impacted targeted participants, especially those who are Hispanic minorities and living in substandard housing, is essential for informing the design of effective interventions and improving respiratory health in the home environment.

Keywords Household characteristics; Childhood asthma, Hispanic families, Health disparities, South Texas, U.S.A

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Background

The Environmental Protection Agency (EPA) has reported that, on average, Americans spend 90% of their time indoors, so indoor air quality is critical to the health of families [1]. Children diagnosed with asthma are exposed to indoor environmental allergens that have different sources such as combustion (tobacco, coal heating, gas appliances, and fireplaces), cleaning supplies, paints, insecticides, and other chemicals including volatile organic compounds, building materials such as chemical off-gassing from pressed wood products and substances in indoor air of natural origin, such as radon, mold, and pet dander [1]. Other in-home environmental exposures include allergenic particles from cockroaches, mice, rats, dust mites [2], dogs and cats, and mold [3]. The role of carpets in accumulating higher levels of dust and allergens than non-carpeted floors has been studied [4, 5]. Ferry et al. reported an association between carpets and early-onset asthma [6]. Tobacco smoke is another common trigger for asthma and its exposure among youth with asthma is a serious public health concern [7].

Social determinants of health (SDH) are increasingly associated with asthma in disadvantaged populations with low incomes living in unhealthy homes, especially in minority populations [8]. Asthma affects approximately 25 million people in the United States, including 4.6 million children under the age of 18. In 2020, nearly one million people visited hospital emergency departments for asthma-related care, and 94,560 people were hospitalized due to asthma [9]. Hispanics in Lower Rio Grande Valley (LRGV) live in Colonias that include a range of housing types that range from substandard to well-built, including small homes, second-hand mobile homes, repurposed airstreams, and makeshift shacks, and it is well-studied that housing stability, quality, safety, and affordability affect health outcomes, as do the physical and social characteristics of neighborhoods [10]. Therefore, we were interested in identifying how substandard housing affects minority Hispanic families with children diagnosed with asthma and how the complications from this condition and low income cause significant challenges to affording basic living needs and good housing [11].

Many environmental factors that affect Hispanic minorities who live in substandard homes are correlated with poor health in children with asthma, especially when conditions inside the home include water leaks, poor ventilation, dirty carpets, and pest infestation. Minority Hispanic families are often relegated to neighborhoods that have substandard housing quality because of systemic racism and low socioeconomic status which results in lower levels of public services and infrastructure availability that exacerbates many environmental justice issues, such as increased exposure to air pollution,

toxins, flooding, and the effects of climate change [12]. Research has provided significant evidence that the causes of asthma are complex and that health-harming housing characteristics collectively exacerbate the risk of asthma or asthma symptoms [13]. Disparities in housing conditions lead to higher incidences of asthma, obesity, hazardous chemical exposures, and lack of healthcare services that make the situation that these families face daily more complicated [14, 15]. Hidalgo County where the LRGV is located had a population in 2022 of 63.6 million, or 19% of the U.S. population [16].

A study done at the US-Mexico Border with a 92.5% Hispanic population identified children diagnosed with asthma through their Independent School Districts who had received asthma education provided to those children and their parents [17]. The education offered was based on the validated American Lung Association Housing and Urban Department Healthy Homes curricula [18] that included information about asthma triggers and how to keep homes free of chemicals [19, 20]. As maintaining homes is expensive, low-income individuals encounter significant challenges in completing repairs to address structural deficiencies that could cause asthma triggers. However, renters are often unable to make any changes in their homes as landlords may not be aware of or may not be concerned by the influence of housing conditions on the asthma control efforts of their tenants [21]. In a report by the Office of the US Surgeon General in 2009, mold and substandard ventilation were reported to contribute to asthma cases in many homes, prompting a call by the Office to promote the Healthy Homes program and curriculum [22].

The goal of this study was to identify the effect of substandard housing quality on asthma symptoms. Our objectives included assessing the impacts of building and flooring types, heating sources, window shading, parental smoking behaviors, moisture and mold in the home, ventilation, and owning a pet on asthma symptom occurrence.

Methods

Population settings

This Asthma and Healthy Homes education program began in 2015 in the rural areas of the Lower Rio Grande Valley of Texas (a US-Mexico border region) to address asthma prevalence and the high number of asthma-related hospitalizations.

Recruitment

We approached numerous Independent School Districts (ISD) in the region for their participation in assisting us to access children diagnosed by a healthcare provider with asthma. Children from four to 18 years

of age diagnosed with asthma by their healthcare provider and parent(s) participated in the study. After their parents signed the consent document, a Community Health Worker (CHW) contacted them for an appointment to provide asthma and Healthy Homes education at their homes. Three hundred and fifty-three children participated in the program after we received the consent of their parents.

Intervention

As part of the Healthy South Texas Asthma Program (HSTAP), a validated survey was used to collect participant household data (i.e., density, home characteristics, mold, carpet, water leakage presence, and pets). This paper presents an analysis of the study population, the household characteristics of study participants, and the impact that asthma had on the participants before the HSTAP intervention. Symptoms were defined based on how often a child has each symptom. When occurring frequently or more than frequently in the last month, they were categorized as 1, and occasionally, rarely, or not in the last month, they were categorized as 0. The bilingual *Asthma and Healthy Homes* curriculum (English and Spanish) has been described elsewhere [19]. Informed consent was obtained from all participants before completing the survey.

Data collection

The study population of the state-funded Healthy South Texas Asthma Program (HSTAP) was comprised of participants enrolled from September 2015 to August 2020, and the data presented here is the HSTAP baseline data. Community health workers (CHWs) conducted surveys with participating parents at the first visit to gather baseline information about the household and building characteristics, and asthma-related health outcomes.

These validated surveys assessed the health outcomes and quality of life of asthmatic children and their families. The Children's Health Survey for Asthma (CHSA), developed by the American Thoracic Society was administered to participating parents to collect information about asthma symptoms, physical activity, and the emotional health of the child and the family [23]. In 2018, the CHSA was replaced by the validated Asthma Pediatric Quality of Life (PedsQL) survey that measures asthma health-related quality of life in asthmatic children [24]. Our decision to change the survey we used was primarily based on the fact that the PedsQL gathered the information we wanted to collect, and due to the length of the survey.

Participant characteristics & survey

The HSTAP initiative was implemented in Hidalgo County, Texas, a region of the US-Mexico borderland that includes both urban and rural communities. It was designed to address the high number of hospitalizations and disease prevalence of families of children with asthma in the region. The county's total population in 2023 was 898,471, of which 32% reported having no medical insurance. According to the US Census Bureau, the median household income in Hidalgo County was \$49,371 in 2023, and the poverty rate in the county was 27.4% [17].

We analyzed study participant characteristics and home environments in detail, including calculating means and standard deviations (SD). Asthma symptoms were dichotomized using frequency scores that described the presence of symptoms "most of the time" or "almost always" being considered the outcome of interest for the presence of each symptom. Logistic regression modeling was conducted to explain the dependence of each asthma symptom on each of the explored independent variables, with the age and sex of participating children as additional adjustment covariables. To ensure goodness of fit, a post hoc test was employed, and for each regression model, a pseudo-R square was calculated. To ensure goodness of fit, the Hosmer-Lemeshow test was performed post hoc, and models were preserved when $p > 0.05$ [25]. Confidence intervals for means and percentages were established at 95%, and $p < 0.05$ was established as the significance level. Stata version 14 was used to perform all of them [26].

Ethics

The Institutional Review Board of Texas A&M University reviewed and approved all study protocols (IRB2015–0472). All participating parents or legal guardians indicated their desire to participate in the study and signed an informed consent form. All methods were performed in compliance with Texas A&M University's relevant guidelines and regulations.

Results

Our study focused on children of low-income families diagnosed with asthma and their parents. The demographics of participants are described in Table 1. Fifty-nine percent of families had an annual income of less than \$14,999; most child participants were male (55.7%), 69% of participating parents were married, and 86% reported a household comprised of a single family.

The characteristics of the dwellings of participating families are summarized in Table 2. Tile flooring was the most used at 38.9%, followed by vinyl at 26.9%, hardwood at

Table 1 Demographic characteristics (N = 350, 2015–2020)

		Count	Percentage
Parent's Gender	Male	15	4.3%
	Female	335	95.7%
Child Gender	Boy	195	55.7%
	Girl	155	44.3%
Income	Less than \$14,999	192	54.9%
	\$15,000-\$29,999	117	33.4%
	\$30,000-\$60,000	31	8.9%
	> \$60,000	10	2.9%
Marital Status	Married	242	69.1%
	Separated	46	13.1%
	Divorced	18	5.1%
	Widow	7	2.0%
	Single	37	10.6%
Number of families per home	Single-family	301	86.0%
	Two families	47	13.4%
	Three or more	2	0.6%

20%, and carpet at 12.9%. 57.7% of participating parents reported owning their homes, and 86.3% reported having curtains. Regarding housing conditions, 238 out of 353 participants reported living in a house, while a single-family inhabited 301 houses and family-owned houses 202. Figure 1 shows that cough was the most prevalent symptom in children with asthma, followed by wheezing with a cold and difficulty sleeping due to symptoms. The least reported symptom was chest tightness.

Figure 2 (Part 1 and 2) shows how housing characteristics influence the symptomatology of children living with asthma. No differences were found between those who live in apartments, houses, mobile homes, or duplexes. Also, no statistical significance was observed between the symptoms of children living in owned or rented homes. Still, when comparing the odds for the difficulty of sleeping among children living with their own family only in contrast to those who live in houses inhabited by more than one family, we found that those who cohabit only with their family had fewer problems sleeping. Detailed data on the association between home characteristics and asthma-related symptoms can be found in Supplementary Material.

We found that children who lived in houses near agricultural areas and in residences with curtains had five times higher rates of shortness of breath than children who did not live near agricultural areas in residences with curtains. We also found an increase in chest tightness in participating children who are exposed to someone smoking inside a car.

Figure 2 shows that single-family homes were associated with lower odds of shortness of breath but

Table 2 Dwellings characteristics (N = 350, 2015–2020)

		Count	Total N %
Building type	House	238	68.0%
	Duplex	5	1.4%
	Flat	43	12.3%
	Mobile home	64	18.3%
Ownership	Owned	202	57.7%
	Rented	148	42.3%
Heating source	Wood-burning	11	3.1%
	Coal	2	0.6%
	Electric	171	48.9%
	Gas	12	3.4%
Flooring type	Central Air	154	44%
	Carpet	45	12.9%
	Hardwood	70	20.0%
	Tiles	136	38.9%
	Vinyl	94	26.9%
Window shadings	Other	5	1.4%
	Curtains	302	86.6%
	Blinds	41	12.0%
AC Unit	Shades	5	1.4%
	Yes	185	53.0%
AC and heating	No	164	47.0%
	Yes	328	93.7%
Fuel-burning heating system	No	22	6.3%
	Yes	7	2.0%
Humidifier	No	343	98.0%
	Yes	22	6.3%
Ventilation in humid space ^a	No	328	93.7%
	Adequate	323	92.3%
Mold present at home	Poor	27	7.7%
	Yes	42	12.0%
	No	308	88.0%

^a Humid spaces are areas used for washing and drying clothes indoors, cooking areas (stoves, dishwasher), and bathrooms. Adequate refers to venting outdoors or following the manufacturer's ventilation recommendation

higher odds for chest tightness. Having pets in the home increased the odds of chest tightness, sleeping difficulty, and wheezing, and the odds of chest tightness were even greater when pets were allowed to be inside the household. Homes located in proximity to agricultural fields may pose an additional exposure for children diagnosed with asthma, with an OR of 5.51 (5.17–5.84). Having curtains in the windows was associated with an increase in the odds of both shortness of breath and cold. Our analysis showed that children who had difficulty sleeping were exposed to aerosols, lived in proximity to standing water near their homes, kept their pets inside the house, had stuffed toys in the room, and/or had carpets on the floor. In contrast, we

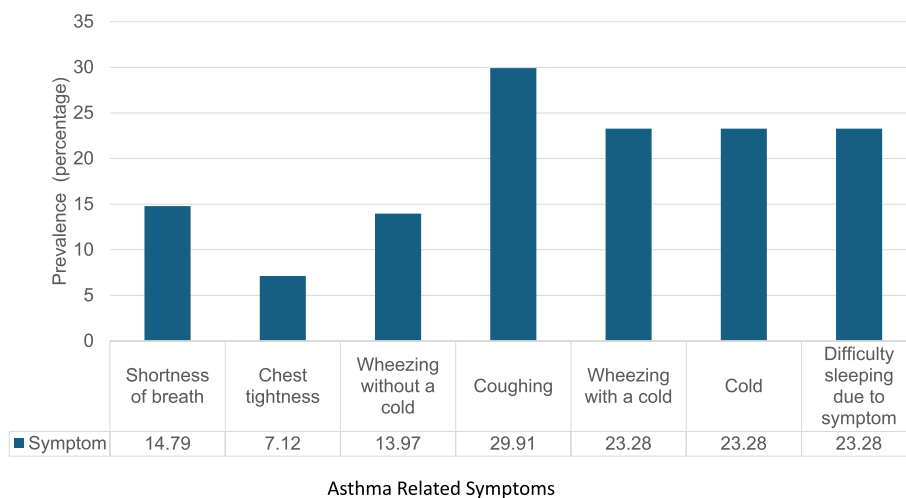


Fig. 1 Prevalence of asthma symptoms in the last month among children whose parents responded to the home environment and asthma-related factors questionnaire ($n=365$)

found that children in a single-family home were less prone to sleep difficulties and that participants who reported that they had received vaccination against the flu reported significantly reduced risk of chest tightness and shortness of breath. Additional information on all reported home environment characteristics can be found in the supplementary material.

Discussion

We investigated the relationship between children with asthma living in substandard housing and identified indoor household asthma triggers, environmental factors, and asthma symptoms. Our results differed from those of the Sun Y et al. study, which found that people living in trailers or mobile homes experienced higher asthma risks and were more likely to have problems related to high moisture levels in the home [27].

Regarding heating sources, our data indicated that the choice of heating method could play a role in reported symptoms. Coal heating was linked to an increased severity of chest tightness, while wood burning was associated with higher scores in some symptoms. However, the limitations inherent to this study related to the self-reported nature of interviews warrant caution in interpreting these findings. The study by Abebe et al. found a positive relationship between wood burning and asthma, while Nriagu et al. did not find a positive correlation between asthma and using wood as a heat source [28, 29].

We explored the potential impact of flooring types on asthma outcomes and found that carpeting in the home influences wheezing without a cold. Our analysis

of window shading types emphasized the importance of regular cleaning to prevent dust accumulation that can impact indoor air quality and exacerbate asthma symptoms. The role of carpets in accumulating higher levels of dust and allergens than non-carpeted floors has been well studied and provided evidence of an association between the use of carpets and early-onset asthma [4, 6, 30]. However, the findings of our study only showed difficulty sleeping due to asthma symptoms. Our analysis of window shading types emphasized the importance of regular cleaning to prevent dust accumulation that can impact indoor air quality and exacerbate asthma symptoms.

Our data indicate that the presence of leaks/moisture had a high association with shortness of breath. The Wang et al. study found that mold and dampness in houses were associated with allergic rhinitis and asthma [31]. Moisture that leaks inside the house from both external and internal sources, when coupled with inadequate ventilation, can result in elevated moisture levels throughout the home. This moisture can then precipitate into condensation on cold surfaces, which creates a significant risk of dampness in colder homes [32]. Finally, our data suggested an association between proper ventilation and higher average scores for most asthma-related symptoms, indicating potentially better health outcomes. Substandard ventilation inside homes is associated with an increased risk of asthma symptom exacerbation and respiratory tract infections in children [33]. Improving ventilation in homes reduces the concentration of allergens and particulates that can exacerbate respiratory symptoms, and there is evidence that children living in homes with adequate ventilation can experience

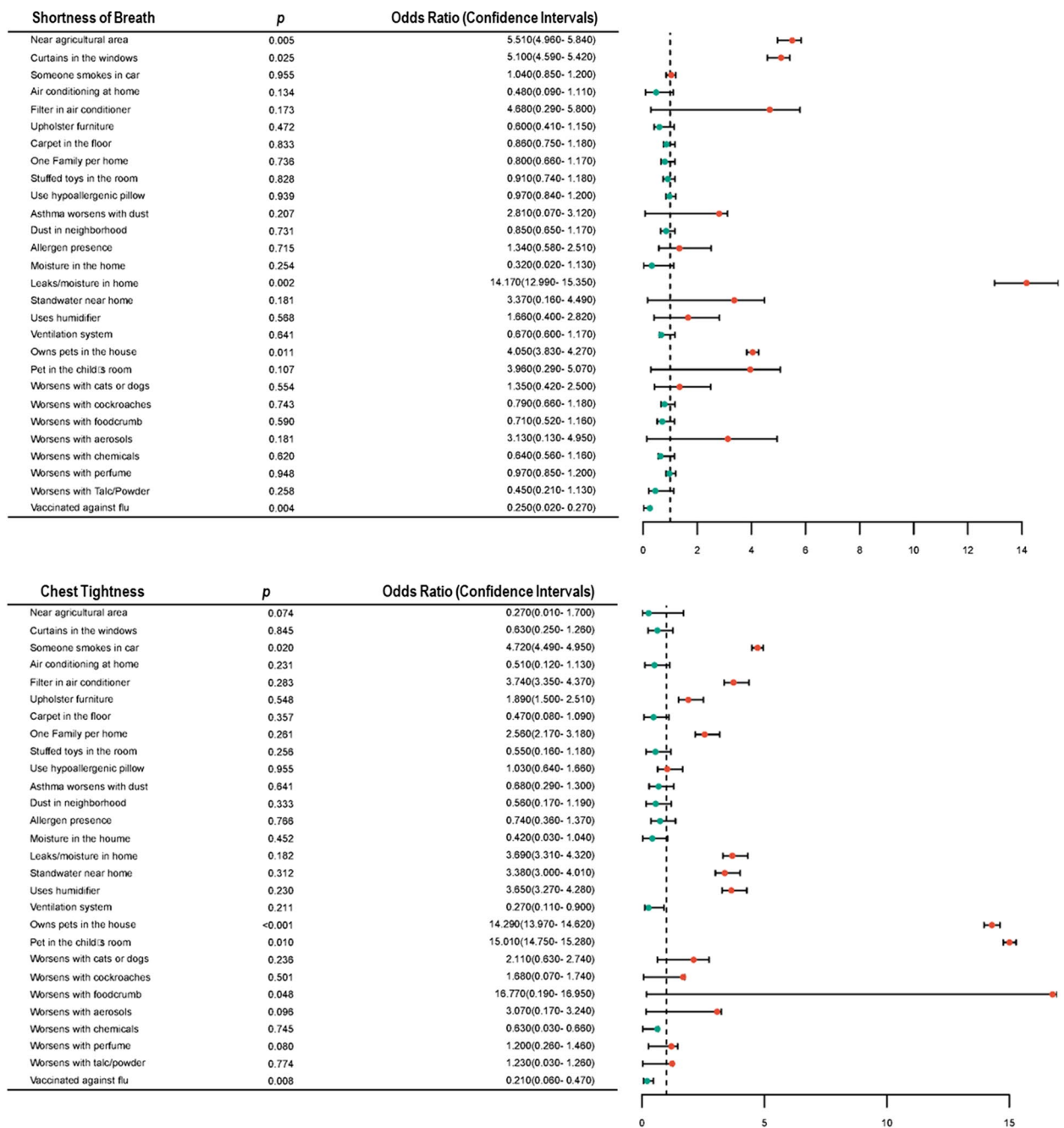


Fig. 2 Forrest plots from logistic regression models expressing Odds ratio and confidence intervals for asthma-related symptoms in association with home environmental triggers and type of asthma characteristics ($n = 365$) in a sample of families with children diagnosed with asthma (Part 1). All independent variables are dichotomous; the presence of each factor was coded as 1 for reference (vertical lines) and the absence was coded as 0. Odds ratio with > 1.00 and $p < 0.05$ mean proneness to the corresponding asthma symptom and Odds ratio < 1.00 represent protective factors for the correspondent asthma symptom. **Each symptom was defined as dependent variable in regression model including home environment exacerbating factors

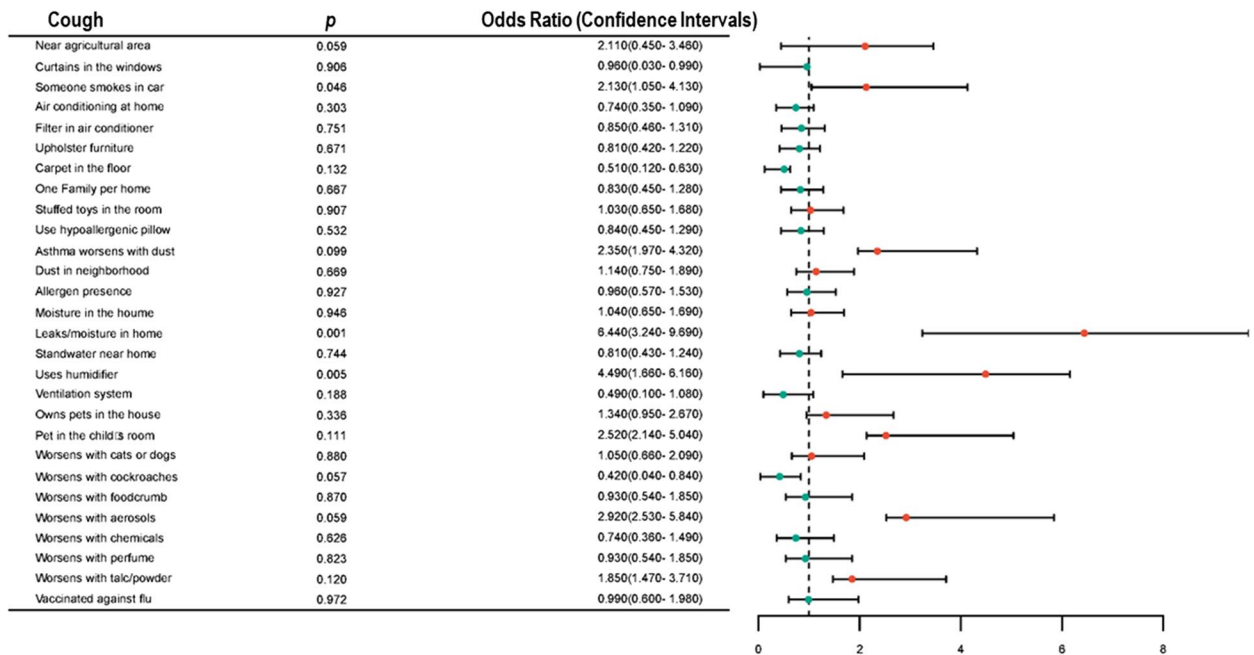
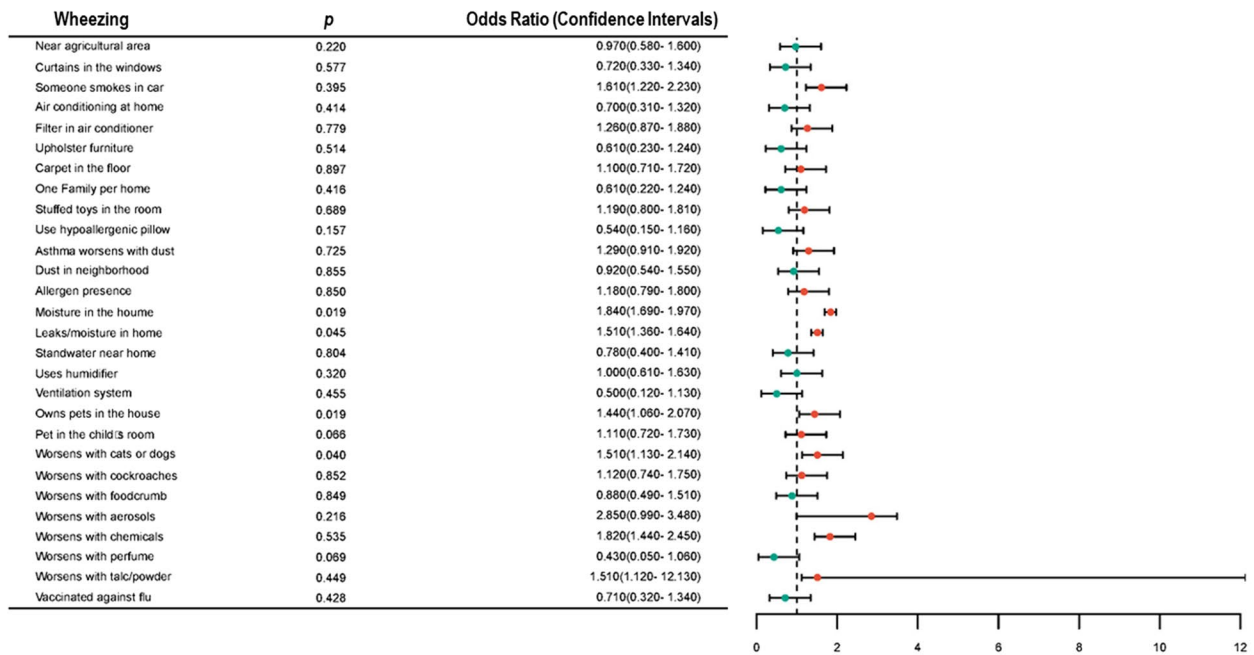


Fig. 2 continued

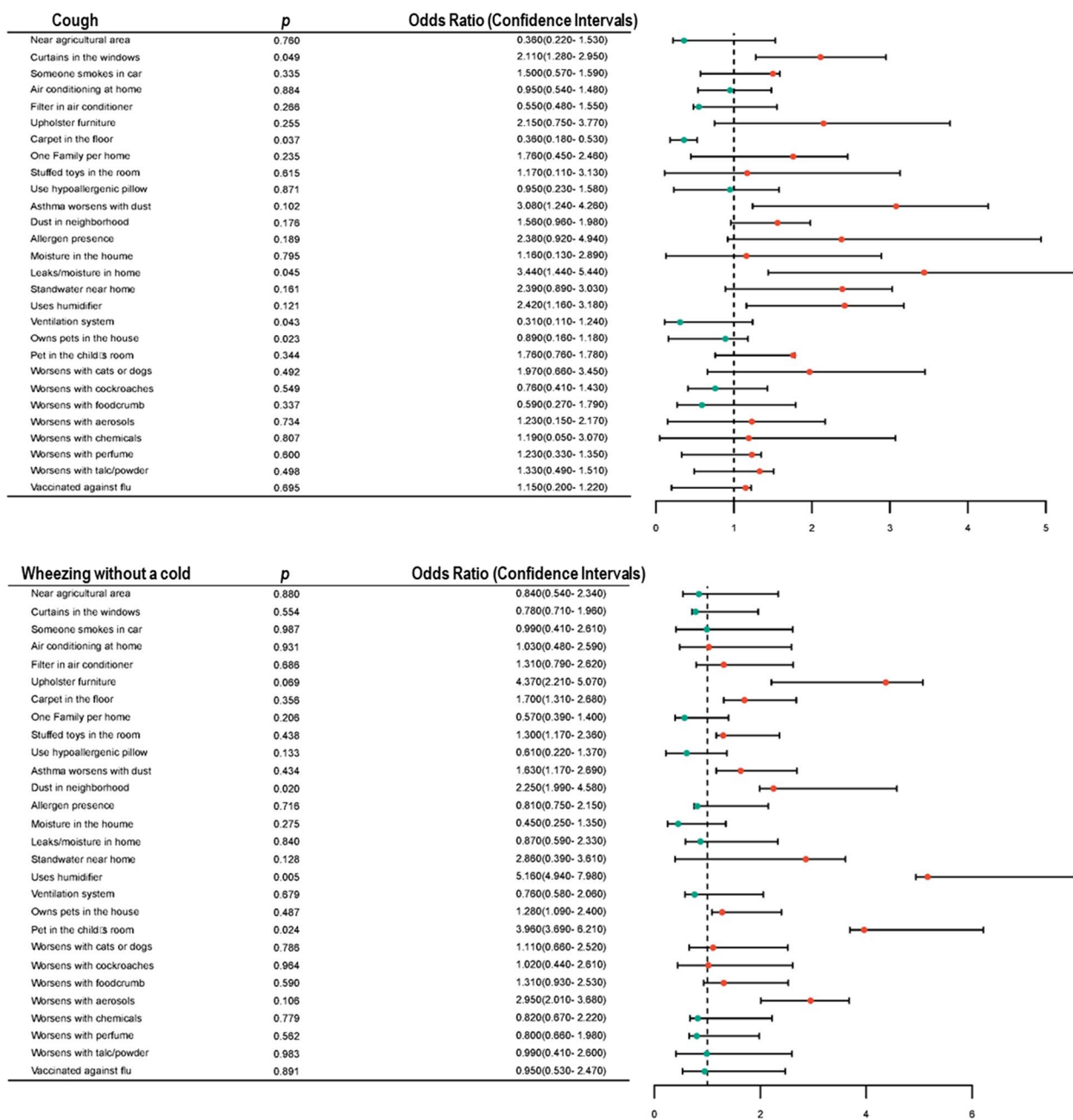


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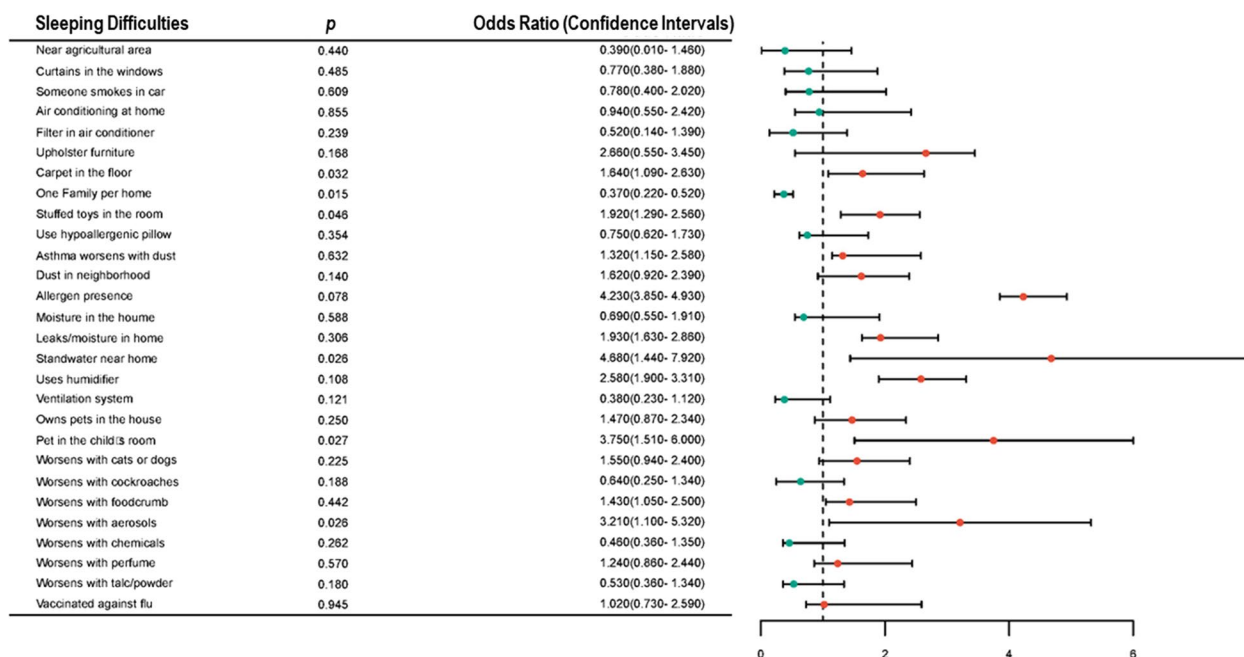


Fig. 2 continued

improved asthma outcomes and are at a significantly lower risk for respiratory tract infections [34].

Our study highlights how a variety of environmental factors, such as living near an agricultural area and having curtains, can increase shortness of breath, and having water leaks in the home and the excess moisture that is related to such leaks can increase shortness of breath, wheezing, coughs, and colds. Another important exposure is associated with having a pet inside the home, which our data indicates is associated with increased chest tightness. In our analysis determining the association between smoking and asthma symptoms, we found that smoking inside a car was associated with an increase in chest tightness and cough in children with asthma. A comprehensive understanding of the association of these factors and the targeted participants, especially those who are members of historically underserved minoritized communities living in substandard houses, is essential for informing the design of effective interventions and improving respiratory health in the home environment. Limitations to the present study are inherent to its cross-sectional design, which does not allow for the estimation of causality between the environmental factors assessed and asthma symptomatology.

Conclusions

The built environment has an important impact on the health of Hispanic children with asthma when their families live in substandard housing near agricultural fields,

use curtains, have water leaks and excess moisture in their house, and have inside pets. Families with these risk factors should be aware of an increased risk of asthma symptom severity, shortness of breath, chest tightness, wheezing, coughs, and colds. Indoor furniture, carpets, curtains, and any other objects prone to accumulating dust may also result in an increased exacerbation of symptoms, as these textiles favor an increase in the retention and concentration of allergens inside the home. Educating parents and children with the bilingual *Asthma and Healthy Homes* curriculum (English and Spanish) during the study period has been shown to improve the quality of life of families and children, reduce the incidence of asthma attacks and improve asthma symptoms [35–37].

Abbreviations

- HSTAP Healthy South Texas Asthma Program
- PARE Program on Asthma Research and Education
- ISD Independent School District.
- HUD Department of Housing and Urban Development
- CHW Community Health Worker
- CHSA Children's Health Survey for Asthma
- PedsQL Asthma Pediatric Quality of Life Questionnaire

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s44329-024-00010-6>.

Supplementary Material 1.

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Authors' contributions

GC and AMR: Conceptualization. GC: Methodology and Data collection. AMR and NMD: Data analysis. GC: Writing and Original draft preparation. GC, NMD, and AMR: Review and Editing. All authors have read and agreed to the published version of the manuscript. The author(s) read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The Institutional Review Board of Texas A&M University granted ethical approval of all research protocols and educational curricula. All participating parents and/or legal guardians signed informed consent forms for the study. All research protocols were performed following the relevant guidelines and regulations of Texas A&M University.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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