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Household food insecurity is associated with asthma control in Peruvian children living in a resource-poor setting

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ABSTRACT

Rationale: Prior evidence suggests that there may be an association between asthma and food insecurity. We sought to describe the prevalence of food insecurity access, defined as having sufficient resources for appropriate foods in Lima, Peru, and evaluate its association with asthma status and control.

Methods: We analyzed data from 553 children with asthma and 268 healthy controls aged nine to 19 years living in two peri-urban communities in Lima, Peru, in 2013. We used the Household Food Insecurity Access Scale to assess food insecurity. We defined uncontrolled asthma as an asthma control test score ≤ 19 . We used multivariable logistic regressions to determine the relationship between asthma outcomes and food insecurity adjusting for age, sex, socioeconomic status, body mass index, and setting.

Results: Average age was 14.2 years (SD 2.7). There was a high prevalence of household food insecurity in our study: 330 participants (40.2%) were food insecure, and average food insecurity access score was 2.7 points (SD 4.2). While being food insecure was not associated with asthma status (OR = 1.23, 95% CI 0.85 to 1.79; $p = 0.28$), it was associated with a higher odds of having uncontrolled asthma (OR = 2.01, 95% CI 1.13 to 3.59; $p = 0.02$). Each one-unit increase in food insecurity score (higher scores indicating more insecurity) was associated with 8% higher odds of having uncontrolled asthma (OR = 1.08, 95% CI 1.02 to 1.14; $p < 0.01$).

Conclusions: Worse asthma control was associated with food insecurity. Future studies are needed to better understand the role of food security in determining the success of treatment strategies.

Abbreviations: ACT: asthma control test; BMI: body mass index; HDS (score): healthy diet score; HFIAS: household food insecurity access score; ISAAC: International Study of Asthma and Allergies in Childhood; SES: socioeconomic status; FEV₁: forced expiratory volume in 1 second; FVC: forced vital capacity; LMICs: low- and middle-income countries; USDA: United States Department of Agriculture

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Introduction

Asthma is a heterogeneous disease leading to chronic airways inflammation (1,2) and has become one of the most prevalent non-communicable diseases worldwide (3). The prevalence of asthma has been increasing with urbanization and westernization in low- and middle-income countries (LMICs) (4,5). In 2006, asthma prevalence in Peru was 13% (4) with a more recent estimate of 12% in Lima (6). Multiple factors have been implicated in the pathogenesis of asthma, including micronutrient deficiencies and dietary

inadequacy (7,8). While no specific vitamin or micronutrient thus far has been consistently associated with asthma or allergies (9), other studies have shown that overall dietary patterns such as the Mediterranean diet or westernized diet are associated with allergic disease or asthma outcomes (10).

Food security exists when populations have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life (11). Food insecurity has been shown to be adversely associated with the health

of adults and growth in children (12,13), as well as micronutrients deficiency in adolescents (14).

The mechanism underlying this association is likely dietary intake of lower quality in food insecure individuals as compared to food secure individuals. Food insecurity of any severity is associated with decreased dietary intake (15–17), poor child feeding practices (18), and suboptimal health outcomes (19–21) in LMICs (16,22).

In a recent study, moderate and severe food insecurity was associated with higher odds of having asthma symptoms, such as wheezing in the previous year compared to food secure participants (23). However, factors that lead to the development of asthma may not be the same as those that lead to worsened disease control. Few studies have examined whether food insecurity is associated with disease morbidity or disease management in subjects with established asthma (24). Whether food insecurity affects asthma control in individuals who already have asthma is also unclear. We sought to determine the prevalence of food insecurity access using a validated survey in a cohort of children and adolescents living in two peri-urban communities of Lima, Peru. In addition, we explored the relationships between levels of food insecurity access and asthma outcomes including asthma control.

Methods

Study setting

The study took place in two peri-urban communities, Pampas de San Juan de Miraflores (Pampas) and Villa El Salvador (Villa), located approximately 25 km south of central Lima, Peru.

Study design

This is an ancillary analysis of an unmatched case-control study conducted in the peri-urban communities of Pampas and Villa in Lima, Peru. A total of 821 children aged 9–19 years with and without asthma, were recruited from the parent Genetics of Asthma Susceptibility to Pollution (GASP) study, which used a population-based census survey to identify the study population. Of the 666 children with asthma invited to participate in this ancillary study, 553 (83%) completed the Household Food Insecurity Access Scale (HFIAS) questionnaire. Of the 511 children without asthma, 268 (52%) were randomly selected to complete the questionnaire. Participants with a chronic respiratory condition other than asthma and those who were pregnant were excluded. Children without asthma were those never diagnosed with asthma by a physician, had no

symptoms consistent with asthma nor used medications for the treatment of in the past year, and had a forced expiratory volume in 1 s (FEV_1) > 80% predicted and FEV_1/FVC > 85%. We enrolled only one child per household. Parents or legal guardians provided written informed consent and children provided assent. All materials and protocols were approved by the Internal Review Boards of Johns Hopkins School of Medicine in Baltimore, USA (IRB_NA_0037696) and Asociación Benéfica PRISMA, in Lima, Peru.

Data collection

Data were collected between March 2013 and February 2014. Questionnaires were administered to participants and their parents or legal guardians. Demographic, socioeconomic status (SES), and health-related information were collected at baseline. An SES score was developed using a Principal Component Analysis using household variables that included individual household assets, size, and parental education. Lower scores indicate higher levels of poverty.

All participants underwent screening to determine and confirm their asthma or control status based on the validated Spanish-translated questionnaire from the International Study of Asthma and Allergies in Childhood (ISAAC) (25). We measured anthropometry including weight, height, waist, hip, and wrist circumference (26). Body mass index (BMI) was calculated from weight and height (kg/m^2) and classified according to the Extended International BMI cut-offs points according to age and sex: thin (values ranging anywhere from <13.2 to <17 kg/m^2), normal (with the lower range starting at 13.2 kg/m^2 and the upper range being <25 kg/m^2), overweight (with the lower range starting at 19.1 kg/m^2 and the upper range being <30 kg/m^2), and obese (values ranging from >22.8 to >30 kg/m^2) (27–29). Finally, dietary intake information was obtained from food frequency questionnaires and further developed into a Healthy Diet Score (HDS) that summarized the daily frequency intake of healthy and unhealthy food groups, previously associated with respiratory diseases (data not shown).

Outcomes

The two study outcomes were asthma status and asthma control. Children with asthma were defined as having a physician diagnosis, and either self-reported wheezing or use of asthma medications in the last 12 months. Asthma control was assessed among participants with

asthma, using the validated, Spanish-translated Asthma Control Test (ACT) points. Uncontrolled asthma was defined as an ACT score ≤ 19 points (30–32).

Food insecurity

Food security information was collected using a Spanish-translated version of the HFIAS. The Access component of Food Security is defined as having enough resources for appropriate foods for a nutritious diet (33). Therefore, food insecurity was defined as the lack of any of these resources. All questions were directed to parents or guardians of the participants (33). This questionnaire reflects three different domains of food insecurity access: anxiety and uncertainty; insufficient quality, and insufficient food intake in the previous four weeks. Household food insecurity access was scored from 0 to 27 with higher scores indicating greater food insecurity access, quantifying the frequency of uncertainty, perceptions of insufficient quantity, and quality of food. Four categories of higher levels of food insecurity were also created from this score: food secure, mild, moderately, and severely insecure as defined elsewhere (33). We then collapsed food security scores into two categories: food insecure or not.

Biostatistical methods

The primary objective of this analysis was to evaluate the relationship between household food insecurity and the odds of having asthma. Secondary analyses included the relationship between the household food Insecurity and asthma control among participants with asthma. We analyzed the Household food insecurity access as a continuous (HFIAS score) and a dichotomous (food insecure or not) variable. We used chi-squared tests for categorical variables as well as

t-test and Mann Whitney tests for continuous variables, respectively.

We used multivariable logistic regression to estimate the odds ratio (OR) at the 95% confidence intervals for the association between asthma outcome and either continuous or dichotomous HFIAS, adjusted for age, sex, BMI, HDS, Socioeconomic Status Score (SES), and study site. Furthermore, we analyzed the potential interaction effect of sex, age, BMI and maternal education, on the relationship between household food insecurity and asthma outcomes.

All analyses were performed using STATA 15 statistical software (Stata Corp., College Station, Texas) and R (www-r-project.org).

Results

Participant characteristics

Among the 821 participants, average age was 14.2 years (SD ± 2.7), 53.2% ($n=438$) were male and 67.4% ($n=553$) were children with asthma. We did not identify differences in age (13.4 vs. 13.5 years, $p=0.53$), sex (53.3% vs. 51.6% male, $p=0.59$) or BMI (21.9 vs. 21.5 kg/m², $p=0.06$), between individuals who completed and those who did not complete the HFIAS questionnaire in the study population. We summarized participants' characteristics by food security status in Table 1 and by asthma status in Table 2.

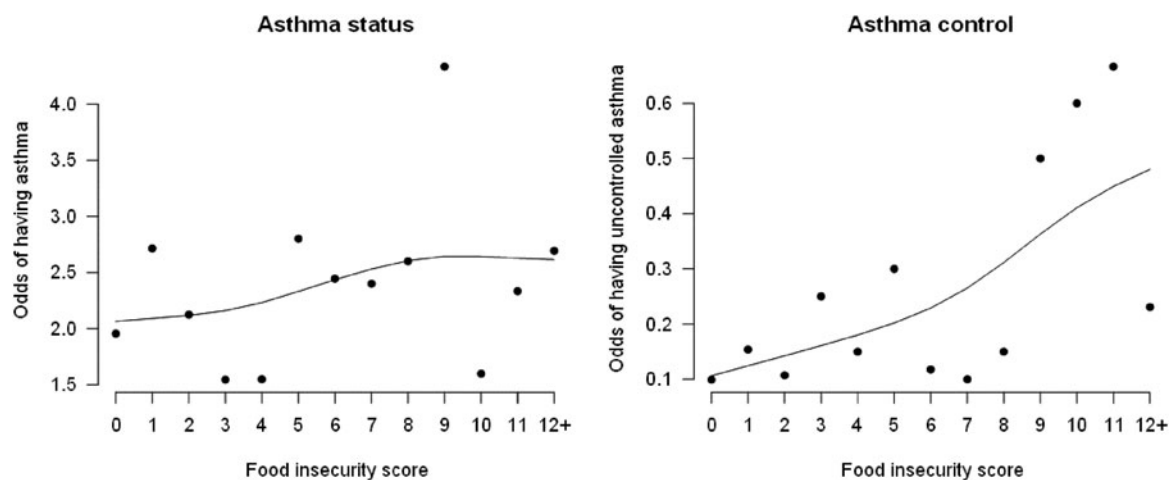
HFIAS scores ranged from 0 to 20 with a mean score (SD) of 2.7 ± 4.2 points. Scores were positively skewed and 57.9% ($n=476$) of participants reported a score of 0. A total of 330 participant households (40.2%) were classified as food insecure. Of the 330 food insecure households, 118 (14.4%) were mildly,

Table 1. Participants characteristics by household food insecurity category.

	Food secure $n=491$	Food insecure $n=330$	Total $n=821$	p
Age in years, Mean (SD)	14.4 (2.7)	13.9 (2.6)	14.2 (2.7)	0.03
Sex, % male (n)	50.1 (246)	57.8 (191)	53.2 (437)	0.03
BMI in kg/m ² , Mean (SD)	22.7 (4.5)	21.8 (4.0)	22.4 (4.4)	<0.01
n =subset of sample	$n=463$	$n=320$	$n=785$	
BMI Cole categories				0.27
Thinness/Normal % (n)	59.8 (277)	63.8 (204)	59.1 (481)	
Overweight/Obese % (n)	40.2 (186)	36.2 (116)	40.9 (302)	
Socioeconomic Status Score, Mean (SD)	0.39 (1.61)	0.13 (1.71)	0.28 (1.66)	0.04
Asthma status				0.31
Asthma, % (n)	66.0 (324)	69.4 (229)	67.5 (553)	
Asthma control, n =subset	273	197	470	0.01
Controlled, % (n)	90.8 (248)	83.3 (164)	87.7 (412)	
Uncontrolled, % (n)	9.2 (25)	16.7 (33)	12.3 (58)	
Site				0.08
Pampas, % (n)	56.2 (276)	50 (165)	53.7 (441)	
Villa, % (n)	43.8 (215)	50 (165)	46.3 (380)	
Healthy Diet Score, Mean (SD)	4.9 (1.3)	5.0 (1.2)	4.9 (1.2)	0.70

Table 2. Participant characteristics by asthma status.

	Asthma (<i>n</i> = 553)	Control (<i>n</i> = 268)	Total (<i>n</i> = 821)	<i>p</i>
Age in years, Mean (SD)	14.2 (2.7)	14.2 (2.7)	14.2 (2.7)	0.90
Sex, % male (<i>n</i>)	55.9 (309)	47.8 (128)	53.2 (437)	0.03
BMI in kg/m ² , Mean (SD)	22.5 (4.4)	21.9 (4.2)	22.4 (4.4)	0.08
<i>n</i> =subset of sample	<i>n</i> = 535	<i>n</i> = 248	<i>n</i> = 783	
BMI dichotomized				0.09
Thin/ Normal % (<i>n</i>)	59.4 (318)	65.7 (163)	61.4 (481)	
Overweight/Obese % (<i>n</i>)	40.6 (217)	34.3 (85)	38.6 (302)	
Socioeconomic Status Score, Mean (SD)	0.3 (1.7)	−0.02 (1.6)	0.2 (1.7)	0.02
Site				<0.01
Pampas % (<i>n</i>)	49.0 (271)	63.4 (170)	53.7 (441)	
Villa % (<i>n</i>)	51.0 (282)	36.6 (98)	46.3 (380)	
Food Security Score				0.08
Mean (SD)	2.8 (4.3)	2.4 (3.9)	2.7 (4.2)	
Food Security Status				0.31
Food secure % (<i>n</i>)	58.6 (324)	62.3 (167)	59.8 (491)	
Healthy Diet Score, Mean (SD)	4.9 (1.2)	5.2 (1.2)	5.0 (1.2)	0.02

**Figure 1.** Dot plot of HFIAS score and the odds of having asthma and uncontrolled asthma.

115 (14.0%) were moderately, and 97 (11.8%) were severely food insecure.

In single variable analysis, we found that younger participants were more likely to be food insecure ($p = 0.02$), whereas female participants were less likely to be food insecure ($p = 0.03$). After adjusting for confounders, SES was significantly associated with both food insecurity measurements: score (adjusted $\beta = -0.61$, 95% CI -0.82 to -0.39 ; $p < 0.01$) and status (adjusted OR = 0.84, 95% CI 0.76 to 0.93; $p < 0.01$). Healthy diet intake was not associated with either food insecurity score ($p = 0.31$) or status ($p = 0.65$).

Association between food insecurity and asthma outcomes

We plotted the unadjusted odds of having asthma and uncontrolled asthma by HFIAS score in Figure 1. There was no clear relationship between having asthma and food insecurity in an unadjusted analysis. Moreover, we did not find an association between

food insecurity and the adjusted odds of having asthma when the score was used continuously (adjusted OR = 1.04 for each point in the HFIAS score, 95% CI 0.99 to 1.08; $p = 0.14$) or when it was categorized as food insecure or not (adjusted OR = 1.23, 95% CI 0.85 to 1.79; $p = 0.28$) (Table 3).

We also plotted the unadjusted odds of having uncontrolled asthma by HFIAS score in Figure 1. Specifically, the odds of having uncontrolled asthma were greater with a higher HFIAS score. In multivariable analysis, the odds of having uncontrolled asthma was 8% higher for each point change in HFIAS score (OR = 1.08, 95% CI 1.02 to 1.14; $p = 0.006$). When we categorized HFIAS score into food insecure or not, the adjusted odds of having uncontrolled asthma was two times greater (adjusted OR = 2.01, 95% CI 1.13 to 3.59; $p = 0.02$) (Table 4) among those who were food insecure compared to those who were not. There was no collinearity between SES and food insecurity (variance inflation factor of 1.1).

Table 3. Asthma status and household food insecurity indicators.

Continuous	OR (95% CI)			
	Single variable Analysis	<i>p</i>	Multivariable Analysis	<i>p</i>
HFIAS score (IQR: 0 to 4)	1.02 (0.99–1.06)	0.22	1.04 (0.99–1.08)	0.14
SES (IQR: -1.01 to 1.72)	1.09 (0.99–1.21)	0.08	1.12 (0.99–1.27)	0.07
HDS score	0.87 (0.76–0.99)	0.04	0.85 (0.73–0.98)	0.03
Age (IQR 11.86 to 16.42 years)	1.00 (0.95–1.06)	0.94	1.09 (1.01–1.18)	0.02
Sex	0.72 (0.54–0.97)	0.03	0.63 (0.44–0.91)	0.01
BMI (IQR 19.39 to 24.49 kg/m ²)	1.03 (0.99–1.07)	0.08	1.03 (0.98–1.08)	0.21
Site	1.81 (1.34–2.44)	<0.01	0.83 (0.55–1.26)	0.39
Categorical (insecure vs. not)				
HFIAS status	1.17 (0.87–1.58)	0.31	1.23 (0.85–1.79)	0.28
SES (IQR: -1.01 to 1.72)	1.09 (0.99–1.21)	0.08	1.11 (0.98–1.25)	0.09
HDS score	0.87 (0.76–0.99)	0.04	0.84 (0.73–0.97)	0.02
Age (IQR 11.86 to 16.42 years)	1.00 (0.95–1.06)	0.94	1.09 (1.01–1.18)	0.02
Sex	0.72 (0.54–0.97)	0.03	0.63 (0.44–0.91)	0.01
BMI (IQR 19.39 to 24.49 kg/m ²)	1.03 (0.99–1.07)	0.08	1.03 (0.98–1.08)	0.19
Site	1.81 (1.34–2.44)	<0.01	0.84 (0.56–1.28)	0.43

Table 4. Asthma control and household food insecurity indicators.

Continuous	OR (95% CI)			
	Single variable Analysis	<i>p</i>	Multivariable Analysis	<i>p</i>
HFIAS score (IQR: 0 to 4)	1.08 (1.02–1.14)	<0.01	1.08 (1.02–1.14)	<0.01
SES (IQR: -1.01 to 1.72)	0.99 (0.84–1.17)	0.93	1.07 (0.88–1.29)	0.49
HDS score	0.96 (0.77–1.20)	0.71	0.97 (0.77–1.23)	0.82
Age (IQR 11.86 to 16.42 years)	0.96 (0.86–1.06)	0.40	0.95 (0.84–1.06)	0.35
Sex	1.12 (0.65–1.95)	0.68	1.11 (0.63–1.97)	0.71
BMI (IQR 19.39 to 24.49 kg/m ²)	0.99 (0.94–1.06)	0.99	1.01 (0.95–1.08)	0.79
Site	1.25 (0.72–2.17)	0.44	0.98 (0.52–1.85)	0.95
Categorical (insecure vs. not)				
HFIAS status	1.99 (1.15–3.48)	0.01	2.01 (1.13–3.59)	0.02
SES (IQR: -1.01 to 1.72)	0.99 (0.84–1.17)	0.93	1.03 (0.86–1.24)	0.74
HDS score	0.96 (0.77–1.20)	0.71	0.95 (0.76–1.20)	0.69
Age (IQR 11.86 to 16.42 years)	0.96 (0.86–1.06)	0.40	0.94 (0.84–1.06)	0.33
Sex	1.12 (0.65–1.95)	0.68	1.11 (0.63–1.95)	0.73
BMI (IQR 19.39 to 24.49 kg/m ²)	0.99 (0.94–1.06)	0.99	1.02 (0.95–1.08)	0.64
Site	1.25 (0.72–2.17)	0.44	1.01 (0.54–1.91)	0.98

Effect modifiers of the relationship between food insecurity and asthma outcomes

When we stratified our analysis by potential effect modifiers of the relationship between food insecurity and asthma control, we found that girls were several times more likely to have uncontrolled asthma (OR = 3.87, 95% CI 1.09 to 13.62; $p = 0.04$) if they were food insecure when compared to those who were not. Neither age ($p = 0.49$), BMI ($p = 0.70$), maternal education ($p = 0.43$), nor site ($p = 0.68$), were associated with an effect modification of the relationship between food insecurity and asthma control.

Discussion

The relationship between food insecurity and asthma outcomes is poorly understood. We found a high prevalence of household food insecurity in this population of school-aged Peruvian children when using the Household Food Insecurity Access Scale. While

there was no association between food insecurity and asthma status, we found that household food insecurity was associated with worse control among those who suffered from asthma.

Similar prevalence rates for household food insecurity were reported in another study conducted in Peru (34). In this study, 47% of participants were classified as food secure, with more families in Lima having the highest food insecurity scores as compared to more rural comparison sites. In our own study, we did not find differences in the prevalence of food insecurity between our two study sites despite varying levels of urbanization and poverty. However, Vargas and Penny used a different measure of food insecurity, the Spanish-translated adapted version of the USDA Food Insecurity and Hunger Module (34), whereas we used the validated Household Food Insecurity Access Score (33).

Our results did not show an association between greater food insecurity and higher odds of having asthma, as previous findings have suggested (11,35).

On the other hand, our results are consistent with previous findings that demonstrate an association between greater levels of food insecurity and worse health outcomes (36–38). For example, Cook et al. found a dose-response relationship between fair or poor health status and severity of food insecurity. Specifically, food-insecure children had twice the odds of having fair or poor health nearly twice as compared to food-secure children (36). Findings of a positive association are not consistent, however. Specifically, Hendrickson et al. did not find a significant association between household food insecurity and negative asthma outcomes (39).

Our study has several strengths. This study enrolled a large sample of children in comparison to other household food insecurity studies. To our knowledge, this is one of the first studies of the association between food insecurity and asthma outcomes among Peruvian children and adolescents from peri-urban settings. Other food security studies in Peru did not consider an association with asthma in their analyses and used different methodologies to assess food security (34). Furthermore, the Household Food Insecurity Access Scale questionnaire measures both household and individual food insecurity status and has been validated as a simple, yet effective, method to assess food insecurity access in different settings (40–42); in addition, it has been shown to be acceptable and valid for multi-country research settings (13). Therefore, our findings may be relevant to underserved populations at high risk of asthma morbidity, like our setting.

We recognize some potential shortcomings as well. First, we were unable to establish temporality or causality in this association. The household food insecurity questionnaire used in this study assessed food insecurity in the previous four weeks, and thus cannot be used to evaluate temporality nor long-term effects of food insecurity on asthma/asthma control. Second, this study was not designed *a priori* to examine the relationship between asthma outcomes and food insecurity. Thus, we are aware of the limitations of a case-control study design, sampling method employed, and the small sample size. As such, our findings need to be further validated by studies that are specifically designed to examine the relationship between asthma and food insecurity, such as cohort studies. Third, it is unclear what is the mechanism by which food insecurity is associated with asthma control as our results do not suggest that it is mediated by socioeconomic status, and food insecurity was not associated with a healthy diet score. There might exist other economic factors associated with the access component of food insecurity which may be setting-dependent. In the current study, participants with food insecurity appeared to have

higher levels of poverty as compared to those who were food secure. Norback et al. found an association between socioeconomic factors and rhinitis among children in China (43) while Mangini et al. reported that the positive association between food insecurity and asthma was strengthened by household poverty in US school-aged children (35). Furthermore, few children in our sample used inhaled corticosteroids (44), and as a result, we did not include this variable in our analyses. Second-hand smoking was not considered in the final models as no association was found with asthma status (OR = 0.85, 95% CI 0.60 to 1.21; $p = 0.37$) or asthma control (OR = 1.28, 95% CI 0.67 to 2.47; $p = 0.46$). Further research is needed to determine the extension of our findings to different populations of children with asthma, and to confirm whether food insecurity represents an important factor on the development and management of asthma. Longitudinal studies to study this association are needed. Dietary diversity has been recently reported as a potential mediator between the association of food insecurity and children nutritional status in developing countries (45) while dietary patterns have been associated with asthma outcomes in this study setting (10).

The possible link between asthma and food insecurity has potential implications for social policies that promote food security; the same can be said for the association between greater food insecurity and worse asthma control seen in this population.

Given the complexity of assessing food security, tools like the Household Food Insecurity Access Scale can give us a readily-assessed overview of the access component of food insecurity status in different study populations. Moreover, it can be used to determine the association between food insecurity and diseases which can be used to support comprehensive interventions in which food security is also considered as a factor in the successful treatment of diseases.

Conclusions

We found a high prevalence of household food insecurity access in our study population of children aged 9 to 19 years. Although our results do not support an association between food insecurity and higher odds of asthma, we found that food insecurity was associated with worse asthma control. Future longitudinal studies should evaluate the association between food insecurity and worse asthma control further; and, food insecurity might represent a target for future or public policies aiming to reduce the burden of asthma.

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Author contributions

NH and WCH take responsibility for the overall content, design and conduct of the study. NH, WCH, CETM, KRM, SLP, RMGD participated on the study design, data collection, quality control, and analysis. All the authors were involved in various aspects of the study process, and wrote, reviewed and approved the final manuscript for publication.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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