

## ORIGINAL ARTICLE

# Asthma hospitalization in Vietnamese children: Prevalence and determinants from a pediatric clinic-based study

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## ABSTRACT

**Background and aim:** Asthma is a leading cause of pediatric morbidity, with hospitalizations reflecting poor disease control and healthcare burden. Evidence on asthma-related hospital admissions among Vietnamese children remains limited. This study aimed to determine their prevalence and identify associated factors using recent clinical data from a large pediatric cohort.

**Methods:** A cross-sectional study was conducted among children aged 4–16 years with asthma who attended one of the largest pediatric asthma clinics in southern Vietnam. This secondary analysis included 339 children and their caregivers managed at the center between May 2024 and May 2025. Data were analyzed using R version 4.5.1. Factors associated with hospitalization were identified using LASSO selection and multivariable logistic regression, with adjusted Generalized Variance Inflation Factors (GVIFs) used to assess multicollinearity.

**Results:** Among 339 children (mean age  $7.3 \pm 2.7$  years; 56.0% male), 37.5% experienced at least one hospitalization for asthma exacerbation. In multivariable analysis, uncontrolled asthma (aOR=2.33; 95% CI: 1.42–3.82;  $P < 0.001$ ), longer disease duration (>5 years: aOR=3.21; 95% CI: 1.28–8.10;  $P = 0.013$ ), and preterm birth (aOR=2.53; 95% CI: 1.10–5.83;  $P = 0.029$ ) were significantly associated with hospitalization. Exposure to pet dander was also associated with higher odds of hospitalization (aOR=2.12; 95% CI: 1.05–4.29;  $P = 0.037$ ), whereas having a caregiver who was a housewife was associated with lower odds (aOR=0.46; 95% CI: 0.22–0.98;  $P = 0.044$ ). The final model demonstrated good fit without evidence of multicollinearity.

**Conclusions:** Asthma-related hospitalization among Vietnamese children remains high. Strengthening asthma control and targeted interventions for high-risk groups may help reduce preventable hospital admissions. ([www.actabiomedica.it](http://www.actabiomedica.it))

**Key words:** asthma, hospitalization, factors, pediatrics, Vietnam



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## Introduction

Asthma is a chronic inflammatory disease of the lower airways, characterized by persistent airway inflammation and hyperresponsiveness to various stimuli, leading to symptoms such as dyspnea, cough, chest tightness, and wheezing (1,2). Asthma affects approximately 300 million people worldwide and accounts for an estimated 1,000 deaths per day (2). The global epidemiology of asthma varies substantially across countries and regions, with inconsistent trends over time, and it remains a substantial health burden in children, often persisting into adulthood (3,4). Asthma hospitalization refers to cases in which patients require inpatient care due to severe or uncontrolled exacerbations despite outpatient management. It is one of the leading causes of emergency department visits and hospital admissions among children (1). Syssoyev et al. reported a hospitalization incidence of 6.91 per 1,000 person-years among 31,525 outpatients, of whom 2.8% were admitted. Asthma incidence ranged from 67.5 to 185.9 per 100,000 in boys and 38.2 to 115.7 in girls, with the highest rates observed in children aged 5–11 years, who also had a 2.6-fold higher hospitalization risk than those aged 0–4 years, during the period from 2014 to 2021 (5). Rashid et al. reported 48,217 pediatric asthma hospitalizations in Australia between 2007 and 2022, with 21.6% readmitted within 12 months - predominantly children aged 2–4 years - incurring AU\$15.6 million in direct medical costs (6). Therefore, identifying the factors associated with asthma hospitalization in children is an important issue. Multiple studies have identified a range of factors associated with increased risk of asthma hospitalization in children. Some patient-related factors have been identified, including age, sex, ethnicity, poor asthma control, comorbidities such as gastroesophageal reflux disease, bronchopulmonary dysplasia, respiratory infections, allergic rhinitis, and acute rhinosinusitis, perinatal history (prematurity, low birth weight), and poor adherence to asthma treatment or irregular follow-up (5,7–9). In addition, caregiver- and environment-related factors have also been reported, such as caregiver age, socioeconomic status, tobacco smoke exposure, the presence of pets, have been shown to contribute substantially to the risk

of hospitalization (10–13). However, the majority of available evidence originates from high-income and developed countries (5,9,13–15). Data from Vietnam, a country with distinct cultural, social, and health-care characteristics, remain limited and focus only on a few specific factors (16,17). For these reasons, we conducted this study to determine the prevalence of asthma hospitalization in children and to identify associated risk factors. This research aims to fill a critical knowledge gap in pediatric asthma management and prevention in Vietnam, thereby contributing to improved care and treatment strategies.

## Method

### *Study design, settings, and participants*

A cross-sectional study was conducted among children aged 4–16 years with a diagnosis of asthma who attended the largest pediatric asthma clinic at the regional central pediatric hospital. This manuscript presents a secondary analysis of data from that study (18). Eligible participants were children who had been managed at our center for at least one month between May 2024 and May 2025. Children, or their caregivers, who were unable to complete the asthma control test or other asthma-related questionnaires were excluded. Additionally, participants were excluded if either the child or the caregiver declined participation at any stage; in such cases, both members of the dyad were excluded. This secondary analysis included the entire sample from the original study, comprising 339 children with asthma and their caregivers who were eligible for further analysis.

### *Data collection*

Data pertaining to children with asthma and their caregivers were obtained from medical records and face-to-face interviews with the caregivers. The collected information included demographic characteristics, medical and family history, asthma triggers, comorbid conditions, asthma control status, and asthma severity, as well as caregiver demographics, education level, occupation, and knowledge

regarding asthma. Asthma hospitalization was defined as any inpatient admission in which asthma was documented as the primary diagnosis or the main reason for hospitalization within the past 12 months, based on information obtained from caregiver interviews and/or confirmed in the patient's medical records. Asthma control was assessed using age-appropriate instruments: the Childhood Asthma Control Test (C-ACT) for participants aged 4–11 years and the Asthma Control Test (ACT) for those aged 12 years and older (19,20). A total score of  $\leq 19$  on either scale indicated uncontrolled asthma, whereas a score  $> 19$  denoted controlled asthma. Asthma severity was determined in accordance with the Global Initiative for Asthma (GINA) 2023 classification, which categorizes severity as mild, moderate, or severe (21). Asthma triggers and caregiver knowledge were evaluated using instruments consistent with a previous study (22). Short-acting  $\beta_2$ -agonist (SABA) overuse was defined based on GINA criteria as the use of three or more canisters per year or one or more canisters per month (21).

### Statistical analysis

All statistical analyses were performed using R software, version 4.5.1 (R Foundation for Statistical Computing, Vienna, Austria). Descriptive statistics were used to summarize participant characteristics. Categorical variables were presented as frequencies and percentages. For continuous variables, both means with standard deviations (SD) and medians with interquartile ranges (IQR) were reported to provide a comprehensive summary of the data distribution. Group comparisons were conducted according to data normality: the chi-square test or Fisher's exact test, as appropriate, was used for categorical variables; for continuous variables, differences between the two asthma hospitalization groups were assessed using the independent-samples t-test for normally distributed data or the Wilcoxon rank-sum test for non-normally distributed data. To identify potential explanatory variables, a Least Absolute Shrinkage and Selection Operator (LASSO) regression was performed, and predictors with non-zero coefficients were selected for

further modeling. Subsequently, univariable and multivariable logistic regression analyses were conducted to examine factors associated with asthma hospitalization, employing the HC1 robust standard error estimator to account for heteroscedasticity. In the final multivariable model, adjusted Generalized Variance Inflation Factors (adjusted GVIFs) were calculated to assess potential multicollinearity among independent variables. Results were expressed as odds ratios (ORs) with 95% confidence intervals (CIs) and corresponding *P*-values. A two-tailed *P*-value  $< 0.05$  was considered statistically significant.

## Results

### General characteristics of study participants

Our study cohort included 339 pediatric patients diagnosed with asthma and their caregivers. Among these children, 37.5% (127/339) experienced at least one asthma exacerbation that required hospitalization within the preceding 12 months. Among the children hospitalized for an acute exacerbation, 36/127 (28.3%) experienced two or more episodes within the past year. The mean age of the children was  $7.3 \pm 2.7$  years, and the majority were male (56.0%). There were no statistically significant differences between the hospitalized and non-hospitalized groups in terms of sex, age, stunting, or asthma severity. Several clinical factors were significantly associated with hospitalization. A higher proportion of children with uncontrolled asthma required hospitalization compared to those with controlled asthma (61.4% vs. 38.6%,  $P < 0.001$ ). The duration of asthma was also significant ( $P = 0.001$ ), with a larger percentage of hospitalized children having had asthma for 1–5 years compared to the non-hospitalized group. Furthermore, a history of preterm delivery was more significantly prevalent in the hospitalized cohort (15.0% vs. 7.1%,  $P = 0.019$ ), as did exposure to air pollution as an asthma trigger (23.6% vs. 14.6%,  $P = 0.037$ ). Detailed demographic and clinical characteristics of the patients with asthma, stratified by hospitalization status, are presented in Table 1.

**Table 1.** Demographic and clinical characteristics of pediatric patients with asthma stratified by asthma hospitalization.

Characteristics	Overall (n = 339)	Asthma hospitalization		P-value
		No (n = 212)	Yes (n = 127)	
Sex				0.968
• Female	149 (44.0%)	93 (43.9%)	56 (44.1%)	
• Male	190 (56.0%)	119 (56.1%)	71 (55.9%)	
Age (years)				0.632
• Mean (SD)	7.3 (2.7)	7.4 (2.8)	7.1 (2.5)	
• Median (IQR)	7.0 (5.0, 9.0)	7.0 (5.0, 9.0)	7.0 (5.0, 9.0)	
Age group				0.405
• 4-5 years	108 (31.9%)	68 (32.1%)	40 (31.5%)	
• 6-11 years	204 (60.2%)	124 (58.5%)	80 (63.0%)	
• 12-16 years	27 (8.0%)	20 (9.4%)	7 (5.5%)	
Stunting	36 (10.6%)	27 (12.7%)	9 (7.1%)	0.102
Asthma control				<0.001
• Controlled	171 (50.4%)	122 (57.5%)	49 (38.6%)	
• Uncontrolled	168 (49.6%)	90 (42.5%)	78 (61.4%)	
Duration of asthma				0.001
• <1 year	164 (48.4%)	119 (56.1%)	45 (35.4%)	
• 1-5 years	146 (43.1%)	77 (36.3%)	69 (54.3%)	
• >5 years	29 (8.6%)	16 (7.5%)	13 (10.2%)	
Low birth weight				0.107
• ≥2500g	312 (92.0%)	199 (93.9%)	113 (89.0%)	
• <2500 g	27 (8.0%)	13 (6.1%)	14 (11.0%)	
Preterm birth	34 (10.0%)	15 (7.1%)	19 (15.0%)	0.019
Weight for gestational age				0.373
• AGA	276 (81.4%)	176 (83.0%)	100 (78.7%)	
• SGA	46 (13.6%)	28 (13.2%)	18 (14.2%)	
• LGA	17 (5.0%)	8 (3.8%)	9 (7.1%)	
Asthma triggers				
• Cold, dry air or rapid weather changes	218 (64.3%)	133 (62.7%)	85 (66.9%)	0.435
• URTI	250 (73.7%)	151 (71.2%)	99 (78.0%)	0.173
• House dust mite	40 (11.8%)	20 (9.4%)	20 (15.7%)	0.081
• Pet dander	54 (15.9%)	29 (13.7%)	25 (19.7%)	0.144
• Secondhand smoke	77 (22.7%)	48 (22.6%)	29 (22.8%)	0.967
• Air pollution	61 (18.0%)	31 (14.6%)	30 (23.6%)	0.037

Characteristics	Overall (n = 339)	Asthma hospitalization		P-value
		No (n = 212)	Yes (n = 127)	
Comorbidities				
• GERD	30 (8.8%)	18 (8.5%)	12 (9.4%)	0.764
• Obesity	94 (27.7%)	61 (28.8%)	33 (26.0%)	0.579
• Food allergy	60 (17.7%)	35 (16.5%)	25 (19.7%)	0.458
• Allergic rhinitis	123 (36.3%)	77 (36.3%)	46 (36.2%)	0.985
• Eczema	22 (6.5%)	14 (6.6%)	8 (6.3%)	0.912
SABA overuse	7 (2.1%)	2 (0.9%)	5 (3.9%)	0.108
Asthma severity				0.598
• Mild asthma	164 (48.4%)	103 (48.6%)	61 (48.0%)	
• Moderate asthma	132 (38.9%)	85 (40.1%)	47 (37.0%)	
• Severe asthma	43 (12.7%)	24 (11.3%)	19 (15.0%)	

Abbreviations: SD: standard deviation, IQR: interquartile range; SGA: small for gestational age, AGA: appropriate for gestational age, LGA: large for gestational age, URTI: upper respiratory tract infections, GERD: gastroesophageal reflux disorder, SABA: short-acting beta-agonist.

### Characteristics of patient’s caregivers

The majority of caregivers were female (74.9%), had completed secondary/high school (60.2%), and had adequate knowledge of asthma (69.6%). There were no statistically significant differences in parental history of asthma, caregiver’s education, occupation, or asthma knowledge scores between the hospitalized and non-hospitalized groups. Characteristics of the caregivers are detailed in Table 2.

### Associated factors related to asthma hospitalization

As a method for principled variable selection, LASSO regression analysis was used to identify the most potential predictors for asthma hospitalization among pediatric patients, as illustrated in Figure 1. The results from this selection step revealed that uncontrolled asthma was the most potential predictor of hospitalization, followed by an asthma duration of 1–5 years, and a history of preterm birth. These three factors, among others prioritized by LASSO, were subsequently validated as independent predictors in the final multivariable analysis. Conversely, the model identified protective factors associated with a lower likelihood of hospitalization, indicating having a housewife

as a caregiver. The variables identified through the LASSO regression selection process were subsequently included in univariable and multivariable logistic regression models to adjust for potential confounders. In this final analysis, uncontrolled asthma, a longer disease duration, and a history of preterm birth were confirmed as independent predictors for hospitalization. The model also revealed that pet dander exposure was an independent risk factor, whereas having a housewife as a caregiver significantly lowered the odds of hospitalization. To assess multicollinearity among the independent variables in the final multivariable model, the aGVIF was calculated. Low aGVIF values, ranging from 1.02 to 1.13, indicated the absence of significant multicollinearity in the regression model. The univariable and multivariable regression analyses are detailed in Table 3.

### Discussion

This study identified several key independent predictors of past-year asthma-related hospitalization among a cohort of 339 children. After adjusting for potential confounders, the risk of hospitalization was significantly increased by factors related to the disease

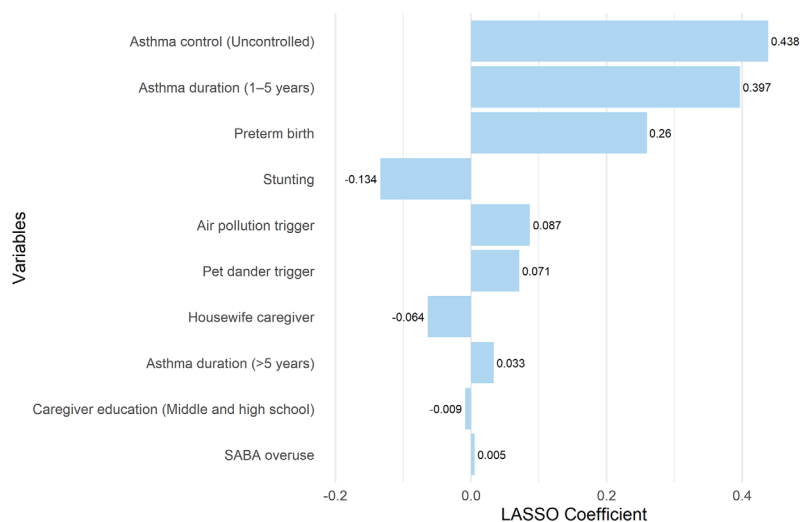
**Table 2.** Characteristics of caregivers/parents of pediatric patients with asthma stratified by asthma hospitalization.

Characteristics	Overall (n = 339)	Asthma hospitalization		P-value
		No (n = 212)	Yes (n = 127)	
Sex				0.320
• Female	254 (74.9%)	155 (73.1%)	99 (78.0%)	
• Male	85 (25.1%)	57 (26.9%)	28 (22.0%)	
Parental history				
• Asthma	41 (12.1%)	28 (13.2%)	13 (10.2%)	0.417
• Allergic comorbidity <sup>†</sup>	103 (30.4%)	66 (31.1%)	37 (29.1%)	0.699
Caregiver's education				0.086
• Primary school	36 (10.6%)	17 (8.0%)	19 (15.0%)	
• Secondary/High school	204 (60.2%)	135 (63.7%)	69 (54.3%)	
• Undergraduate/Postgraduate	99 (29.2%)	60 (28.3%)	39 (30.7%)	
Caregiver's occupation				0.343
• Employment	99 (29.2%)	59 (27.8%)	40 (31.5%)	
• Self employment	122 (36.0%)	73 (34.4%)	49 (38.6%)	
• Housewives	118 (34.8%)	80 (37.7%)	38 (29.9%)	
Caregiver knowledge score				0.940
• Mean (SD)	7.0 (2.8)	7.0 (2.8)	7.0 (2.9)	
• Median (IQR)	8.0 (5.0, 10.0)	8.0 (5.0, 10.0)	7.0 (5.0, 10.0)	
Caregiver knowledge category				0.405
• Adequate	236 (69.6%)	151 (71.2%)	85 (66.9%)	
• Inadequate	103 (30.4%)	61 (28.8%)	42 (33.1%)	

<sup>†</sup>Food allergy, allergic rhinitis, eczema; *Abbreviations:* SD: standard deviation; IQR: interquartile range.

itself, perinatal history, and environmental exposures. These findings underscore the multifactorial nature of severe asthma exacerbations, highlighting a complex interplay between clinical, biological, and socio-environmental determinants. In our study, we recorded a hospitalization percentage for asthma in the past 12 months of 37.5%. This result is comparable to the study by Chen et al. (2022), which reported a percentage of 34.3% (23). Other studies have also reported that the hospitalization rate related to asthma in the preceding 12 months ranged from 12% to 43.6% (24–27). In current study, a significantly greater percentage of children in the hospitalized group had uncontrolled asthma compared to the non-hospitalized group (61.4%

vs. 42.5%, respectively;  $P < 0.001$ ), in the meanwhile a total prevalence of uncontrolled asthma was 49.6%. Nevertheless, this result should be considered with caution because the time frames were different: hospitalization outcome was documented over the previous 12 months, while asthma control was evaluated over the last four weeks. A recent hospital stay may result in a present state of “uncontrolled asthma,” and vice versa, suggesting that this relationship is bidirectional and cyclical. This prevalence of uncontrolled asthma is high, yet it falls within the wide range reported internationally. For instance, a large-scale US survey (2018–2020) from the CDC found that 44.0% of children with current asthma had uncontrolled disease (28). A study in



**Figure 1.** LASSO coefficients for predictors of asthma hospitalization.

Morocco by Maryem et al. (2025) on 203 children with asthma recorded an uncontrolled asthma rate of 53.0% (29). In some African countries, the prevalence of uncontrolled asthma was reported at 30.9% in Nigeria, 31% in Ethiopia, and 44.3% in South Africa among children (30). Another study conducted by Stridsman et al. (2024) have indicated the prevalence of uncontrolled asthma in 5497 children aged 6–17 years was 30.7% (31). The high rate in our study, coupled with its strong association with hospitalization, suggests a critical gap in local asthma management. This can originate from issues such as poor/non-adherence, incorrect inhaler technique, or inadequate caregiver's knowledge and education – all of which contribute to poor asthma control (22,29). The duration of asthma was also significantly associated with hospitalization; children with a diagnosis for 1–5 years contributed a larger percentage of the hospitalized group than the non-hospitalized group (54.3% vs. 36.3%,  $P=0.001$ ). This finding aligns with research from the Childhood Asthma Management Program (CAMP), which demonstrated that a longer duration of asthma in children was independently associated with lower lung function (FEV1/FVC ratio), greater bronchial hyperresponsiveness, and more daily symptoms (32). Chronic, inadequately controlled airway inflammation, even at subclinical levels, can lead to structural changes in the airways known as airway remodeling. This process involves smooth

muscle hypertrophy, subepithelial fibrosis, and mucus gland hyperplasia, resulting in more fixed airflow limitation and heightened bronchial hyperresponsiveness (33). Reinforcing this point, Tran et al. (2024) have shown that a high bronchodilator responsiveness  $\geq 20\%$  was an independent predictor of asthma exacerbation (34). Among environmental factors, reported triggering of asthma by air pollution was significantly more frequent in the hospitalized group. This result is consistent with a findings in a research performed by Chen et al. (2024) which indicated that air pollutants increase the risk of hospitalization for children with asthma, and the impact of air pollutants on children is stronger in the winter (13). This finding is in line with numerous previous studies (35,36). Our study have indicated that history of preterm birth was found in a higher percentage among hospitalized children compared to their non-hospitalized group ( $P=0.019$ ). Several studies worldwide have also indicated a strong association between preterm delivery and an increased risk of acquiring asthma in later childhood (37–39).

### **Associated factors of asthma hospitalization**

The most potent associated factor of hospitalization to emerge from our analysis was the child's current level of asthma control (LASSO coefficient = 0.438). In current study, patients with uncontrolled asthma

**Table 3.** Univariable and multivariable logistic regression analyses with LASSO-selected variables.

Characteristics	Univariable				Multivariable			
	cOR	95% CI	P-value	aOR	95% CI	P-value	aGVIF	
Asthma control							1.04	
• Controlled	Ref			Ref				
• Uncontrolled	2.158	1.375, 3.386	<0.001	2.329	1.420, 3.819	<0.001	1.05	
Duration of asthma								
• <1 year	Ref			Ref				
• 1-5 years	2.370	1.474, 3.809	<0.001	2.346	1.395, 3.946	0.001		
• >5 years	2.149	0.954, 4.839	0.065	3.214	1.275, 8.099	0.013		
Stunting							1.04	
• No	Ref			Ref				
• Yes	0.523	0.237, 1.153	0.108	0.464	0.197, 1.095	0.080		
Preterm birth							1.03	
• No	Ref			Ref				
• Yes	2.310	1.126, 4.740	0.022	2.533	1.101, 5.831	0.029	1.05	
Pet dander								
• No	Ref			Ref				
• Yes	1.547	0.858, 2.787	0.147	2.118	1.046, 4.288	0.037	1.02	
Air pollution								
• No	Ref			Ref				
• Yes	1.806	1.031, 3.164	0.039	1.383	0.732, 2.610	0.318	1.03	
SABA overuse								
• No	Ref			Ref				
• Yes	4.303	0.818, 22.629	0.085	1.719	0.225, 13.147	0.602		
Caregiver's education							1.12	
• Primary school	Ref			Ref				
• Secondary/High school	0.457	0.223, 0.939	0.033	0.521	0.224, 1.212	0.130		
• Undergraduate/Postgraduate	0.582	0.269, 1.259	0.169	0.434	0.161, 1.168	0.098		
Caregiver's occupation							1.13	
• Employment	Ref			Ref				
• Self-employment	0.990	0.575, 1.704	0.971	0.760	0.370, 1.564	0.456		
• Housewives	0.701	0.400, 1.226	0.213	0.461	0.217, 0.980	0.044		

Multivariable analyses were adjusted for age and sex; *Abbreviations*: CI: Confidence Interval, cOR: crude odds ratio, aOR: adjusted odds ratio, aGVIF: adjusted generalized variance inflation factors, Ref: reference category, SABA: short-acting beta-agonist.

had a 2.3-fold increased odds of being hospitalized in the preceding year compared to their well-controlled counterparts (aOR=2.329, 95% CI 1.420–3.819;  $P<0.001$ ). Our result was supported with substantial research indicating that poor control of asthma is a critical and modifiable factor affecting acute health-care utilization, including emergency department visits and hospital admissions (8,40). Al Ghadeer et al. (2024) consistently indicate that children with insufficient control experience more frequent and severe exacerbations need immediate medical intervention (8). Supporting this, Shiyi et al. (2022) have resulted that uncontrolled asthma was more likely to develop acute exacerbations than well-controlled group (OR=6.34, 95% CI: 1.14–35.21;  $P<0.05$ ) (41). A notable finding from our multivariable analysis is the progressively increasing risk of hospitalization with longer asthma duration (1–5 years) (LASSO coefficient = 0.397). The cumulative burden of inflammation and the extent of airway remodeling can be determined by a prolonged duration of disease (32,42,43). By increasing the susceptibility of the airways to severe exacerbations from common triggers, which are frequently less responsive to standard rescue therapies, this underlying pathology would increase the likelihood of hospitalization. This is in agreement with the evidence indicating that a reduced forced expiratory volume in one second (FEV1), a physiological consequence of airway remodeling, is an independent predictor of future asthma attacks and hospitalizations (44). Our research revealed that a history of preterm birth is a strong (LASSO coefficient = 0.26) and independent predictor of pediatric asthma hospitalization (aOR=2.53, 95% CI: 1.10–5.83,  $P=0.029$ ). A meta-analysis performed by Been et al. (2014) reported that preterm birth, particularly very preterm birth, was associated with an increased risk of wheezing disorders (aOR 1.46, 95% CI 1.29–1.65) (39). Similarly, Goyal et al. (2011) have found that in comparison with term gestation, late-preterm gestation (34–36 weeks) was associated with significant increases in persistent asthma diagnoses (aOR=1.68, 95% CI 1.01–2.80,  $P<0.05$ ) (45). Cha et al. (2024) have concluded that as the degree of prematurity increased, the risk of asthma increased in a sequence: the adjusted hazard ratio for the 28–36 weeks of gestational age group was 1.24 (95% CI: 1.22–1.26,  $P<0.001$ ), while

the extremely preterm group had an aHR of 1.51 (95% CI: 1.41–1.63,  $P<0.001$ ) (46). Preterm birth increases the risk of asthma through several mechanisms. First, it interrupts the final critical stages of lung development, leading to a permanent structural deficit and reduced lung function (39,47). This resulting condition often responds poorly to standard asthma therapies (48). Furthermore, the immature immune system of preterm infants increases their susceptibility to severe respiratory infections like respiratory syncytial virus in the first years of life, which are themselves a major independent risk factor for developing persistent wheezing and asthma later in life (49–51). Our investigation of environmental factors has resulted in intricate outcomes. Exposure to pet dander was identified as a substantial independent risk factor for hospitalization (aOR=2.12, 95% CI 1.05–4.29,  $P=0.037$ ), while exposure to air pollutants, significant in the univariable analysis, lost its significance following multivariable adjustment. The association between pet exposure and asthma is highly debated in the literature, with evidence supporting both risk and protective effects (11). Our finding of a higher odds is consistent with a meta-analysis that found that exposure to dogs (RR=1.14, 95% CI 1.01–1.29) and any furry pet (RR=1.39, 95% CI 1.00–1.95) was associated with an increased risk of asthma (52). This finding may seem to contradict the “hygiene hypothesis,” which states that early contact to animals might protect children from the onset of allergies and asthma (53,54). Our research, however, concentrates on a sample of children with an established asthma diagnosis, identifying risk factors for hospitalization. In this context, pet dander serves as an significant allergen, capable of causing an acute inflammatory response in pre-sensitized airways, leading to bronchospasm and the initiation of an asthma episode (55). Recent meta-analysis also support this view, showing that in children who already have asthma, pet exposure is associated with future hospitalization (OR=1.67, 95% CI 1.17–2.37) (40). One of the most novel and statistically significant findings of our study was the protective effect associated with the caregiver being a housewife (aOR=0.46, 95% CI 0.27–0.98,  $P=0.044$ ). A housewife caregiver may have more spare time to dedicate to critical aspects of asthma management (56), including closely monitoring the child for

early signs of worsening symptoms, ensuring strict adherence to daily controller medication schedules (57), implementing environmental control measures within the home (e.g., frequent cleaning to reduce allergen load) (58). Nevertheless, it is also necessary to examine the issue from a bilateral viewpoint. Hope et al. (2017) have indicated that, compared to starting or retaining a job, childhood illness was linked to higher odds of ongoing unemployment (aRRR=1.46, 95% CI: 1.21–1.76) or interrupted employment (aRRR=1.26, 95% CI: 1.06–1.49) and the probability that a mother would leave her job increased if their children had a limiting long-term illness (aOR = 1.27, 95% CI: 1.05–1.54) (59). A research consistently found that mothers of children with asthma are significantly less likely to be employed, particularly in full-time roles, compared to mothers of healthy children (60).

### **Implications of findings**

The results of this study have significant clinical and public health implications for the management of pediatric asthma, particularly in Vietnam. The identification of uncontrolled asthma as the most potent predictor for hospitalization highlights the demands for management and targeted intervention for high-risk patients. The significant association between a history of preterm birth and hospitalization implies that children born prematurely should be identified as a vulnerable population from an early age, requiring stricter monitoring for respiratory issues and active asthma management. In addition, our study has found the protective effect of having a housewife caregiver suggests that increased caregiver time and attention are crucial for effective asthma management. Meanwhile, the significant prevalence of uncontrolled asthma that we found highlights the urgent need for organized patient education and self-management resources. Although it isn't explicitly evaluated in our models, putting written asthma action plans into practice is essential for successful management (61). These plans are frequently given informally (for example, verbally) in the local context rather than as a systematic, regularly offered aspect of treatment. Although there may be challenges because of staffing shortages and healthcare resources, closing this gap by putting in place standardized, easily

accessible action plans could be a crucial tactic for enhancing asthma control.

### **Strengths and limitations**

Our current study possesses several key strengths. The fundamental strength is the development of a comprehensive multivariable model that considers a wide variety of potential risk factors from the clinical, perinatal, environmental, and sociodemographic domains. This integrated approach enables a more thorough comprehension of the multifaceted nature of asthma morbidity. Furthermore, the application of strong statistical methods, such as LASSO regression for principled variable selection that helps to prevent overfitting and identifies the most significant predictors from a large set of variables and subsequent multivariable logistic regression (62–64) with careful multicollinearity evaluations, ensures the reliability and validity of our final model. The study's findings should be interpreted in light of several limitations. First, the causal relationship cannot be established due to the cross-sectional design. For instance, the observed association between uncontrolled asthma and hospitalization may be bidirectional, as a recent severe exacerbation requiring admission would likely result in an "uncontrolled" status. Although this limits causal inference, the robustness of our statistical approach, using LASSO for variable selection followed by a multicollinearity assessment (aGVIF), ensures that the identified associations are statistically independent and reliable, providing strong evidence for targeted interventions. Second, several key variables, including the history of hospitalization, asthma triggers, and disease duration, were based on caregiver-report and are therefore susceptible to recall bias. Third, data on daily treatment, medication adherence, and inhalation technique were collected in the original study. However, these variables were excluded from the regression models due to substantial missing value. The missing data resulted from our cross-sectional design, which evaluated adherence over the preceding three months, thereby excluding information from more recent patients. This three-month snapshot does not align well with the twelve-month hospitalization outcome. The influence of these significant factors necessitates future longitudinal studies.

Finally, as a single-center study conducted in one region of Vietnam, the findings may have limited generalizability to other parts of the country or to different international settings with varying environmental exposures, genetic backgrounds, and healthcare systems.

## Conclusion

The hospitalization rate due to asthma among Vietnamese children remains substantially high. Uncontrolled asthma was strongly associated with hospitalization, indicating its important role in identifying children at higher risk. Longer disease duration and a history of preterm birth were also significant correlates of hospitalization. In contrast, having a housewife as the primary caregiver was associated with a lower likelihood of hospitalization.

**Ethical approval:** Ethical approval for the original study was obtained from the Ethics Committee for Biomedical Research, Can Tho University of Medicine and Pharmacy (IRB No. 24.021.GV/PCT-HDDD, approved on May 20, 2024).

**Conflict of interest:** Each author declares that he or she has no commercial associations (e.g., consultancies, stock ownership, equity interests, patent/licensing, arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

**Authors' contribution:** LCT contributed to the study concept and design; LCT, DTKL, and CNDN were involved in data curation, analysis, and interpretation; DTKL, CNDN, and LCT drafted the manuscript; and LCT critically revised the manuscript for important intellectual content. All authors approved the final version of the manuscript and agreed to be accountable for all aspects of the work, ensuring that any questions related to the accuracy or integrity of any part are appropriately investigated and resolved.

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