

# Predictors of Hospitalization for Asthma in Children: Results of a 1-Year Prospective Study

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**Summary.** Introduction: Although hospital admissions for pediatric asthma constitute a significant problem in high-income countries, they are an even greater health problem in low- and middle-income countries (LMIC). However, previous studies that aimed to identify predictors of hospital admission for asthma in children have mainly been conducted in high-income countries, and these findings might not be applicable to LMIC. Methods: In a prospective cohort study, we aimed to identify predictors of hospital admission for asthma, including measures of parental knowledge about asthma and maternal depression level, in a population of children aged 1–18 years living in urban Bogota, Colombia hospitalized for acute asthma symptoms, over a 6-month period. Results: Out of the total of 101 included patients, 37 (36.6%) had at least one hospital admission for asthma during the year following admission. After controlling for the age of the patients, dog ownership in the previous 12 months, asthma severity variables in the previous 6 months, maternal allergic rhinitis, level of maternal education, and measures of parental knowledge about asthma and maternal depression level, we found that maternal smoking (IRR, 3.12; 95% confidence interval [95% CI], 1.12–8.68;  $P = 0.029$ ) was the only independent predictor of hospital admissions due to asthma exacerbations in the year following admission to the study. Conclusions: In a population of asthmatic Latino children admitted to hospital for an asthma exacerbation, approximately one-third of the patients had at least one hospital admission for asthma during the year following admission, and maternal smoking was the only independent predictor of these hospitalizations. **Pediatr Pulmonol.** © 2013 Wiley Periodicals, Inc.

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## INTRODUCTION

Childhood asthma is the most common chronic disease among children and a major public health problem in the United States as well as in many other countries, such as Colombia.<sup>1,2</sup> The economic burden of this disease is great in terms of both direct medical and indirect costs for families with affected members and for healthcare systems.<sup>3</sup> It has been calculated that emergency department (ED) visits and hospital admissions account for almost three quarters of the direct costs of asthma.<sup>4</sup> Despite significant advances in the treatment of asthma,

particularly over the past 20 years, this disease is a leading cause of hospital admissions among children in various parts of the world.<sup>5</sup> Although these high levels of burden due to the disease constitute a significant problem in high-income countries, they are an even greater health problem in low- and middle-income countries (LMIC) where health resources are always scarce.

Although previous studies have identified important predictors of hospital admission for asthma in children, such as age, gender, race, socioeconomic status, prior asthma hospitalizations, lack of specialized medical care, environmental tobacco-smoke exposure, and indoor

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allergen sensitization,<sup>6–8</sup> these studies have been mainly conducted in high-income countries, and the findings might not be applicable to LMIC, because of differences of race/ethnicity, socioeconomic status, income, cultural barriers, environmental barriers, healthcare systems, and drug and device availability and accessibility between countries, all of which have shown to affect clinical outcomes in asthma.<sup>9–12</sup> Additionally, the majority of these studies only focus on demographic data, such as age, gender, and race, but to our knowledge studies analyzing other modifiable factors that also have been shown to affect clinical outcomes in pediatric asthma, such as parental knowledge about asthma<sup>13</sup> or parental depression level,<sup>14</sup> are very rare.

Accordingly, there is relatively little evidence to date about predictors of hospital admissions in LMIC, and there is a critical need for studies that investigate these predictors in the context of these countries. The identification of predictors of hospital admissions in children in LMIC can contribute to better disease control, reducing the risk of hospital admissions for asthma, optimizing the use of health resources, and consequently lowering the direct costs of the disease.

The aim of the present study was to identify independent predictors of hospital admissions in an acute asthma exacerbation in a cohort of children living in urban Bogota, Colombia.

## METHODS

### Study Population

This prospective cohort study was conducted at Clinica Infantil Colsubsidio, a third-level, multidisciplinary teaching hospital located in Bogota, Colombia. We included a convenience sample of children aged 1–18 years with a previous diagnosis of asthma or respiratory symptoms suggestive of asthma, admitted to the hospital for acute asthma symptoms through the ED, over a 6-month period. Parents/caregivers of participating children were native Spanish speakers living in urban Bogota, with widely varied educational background (at least 5 years of formal education) and socioeconomic status, but with an acceptable reading speed and ability. Patients with concomitant respiratory or cardiac illnesses, gastroesophageal reflux, chronic aspiration, or neuromuscular disease were excluded. While still in the hospital, and after informed consent, all mothers responded to a questionnaire in order to obtain the following baseline parameters: socio-demographic data (age, gender, level of maternal, and paternal education), presence of allergic rhinitis in the patient, parental doctor-diagnosed asthma or allergic rhinitis, maternal and/or paternal smoking, cat and dog ownership in the previous 12 months, information on asthma morbidity in the previous 6 months (number of oral steroids bursts prescribed, number of visits to the ED,

and number of hospital admissions due to asthma exacerbations), and maternal level of depression and degree of knowledge about asthma among mothers of included children.

In order to measure the level of depression in mothers of included children, we used a validated Spanish version of the Zung-Self Rating Depression Scale (ZSDS), a 20-item self-report questionnaire that is widely used as a screening tool, covering affective, psychological, and somatic symptoms associated with depression.<sup>15</sup> There are 10 positively-worded and ten negatively-worded questions. Each item was scored on a four-point Likert-type response scale with answers ranging from “a little of the time” to “most of the time.” The total score of the questionnaire ranges from 20 to 80, with higher scores indicating greater level of depression (Online supplementary Table 1). Based on this total score, patients can be separated into four categories: normal range (20–44), mildly depressed (45–59), moderately depressed (60–69), and severely depressed (70 and above). Likewise, in order to measure the degree of knowledge about asthma among mothers of included children, mothers filled out a questionnaire covering knowledge about asthma that was developed and validated previously by our group.<sup>16</sup> This questionnaire has 17 items grouped into three domains: myth and beliefs about asthma treatment (seven items); knowledge about the disease (six items); and other aspects such as physical activity and cigarette smoking (four items). Each item was scored on a 5-point Likert-type response scale with answers ranging from “strongly disagree” to “strongly agree”. The total score of the questionnaire ranges from 17 to 85, with higher scores indicating greater knowledge about asthma (Online supplementary Table 2).

Although at discharge from hospital all parents received a short explanation of the inflammatory nature of asthma and were instructed to administer continuously inhaled corticosteroids to their children, we did not evaluate the adherence rate to prescribed medications after discharge from hospital.

### Outcome Measure

The outcome of the study was hospital admissions due to asthma exacerbations in the year following admission to the study, defined as a stay in a hospital lasting longer than 24 hr due to an asthma exacerbation. The number of hospital admissions due to asthma exacerbations in the year following admission to the study was determined through a review of electronic medical records of all included patients. For the bivariate analyses, we disregarded the number of hospital admissions, creating a dichotomous variable (yes/no) for the outcome. For the multivariate analysis, we used the absolute number of hospital admissions as the outcome variable.

All parents provided informed consent prior to enrollment in the study, and the study protocol was approved by the local ethics board.

### Statistical Analysis

Continuous variables are presented as standard deviation (SD) or median (interquartile range—IQR), whichever is appropriate. Categorical variables are presented as numbers (percentage). Differences between continuous variables were analyzed using the unpaired *t*-test or Wilcoxon's signed rank test, whichever was appropriate. Bivariate analyses were performed to assess associations between predictor variables and the outcome variable using the Chi-square test or Fisher's exact test, whichever was appropriate. Poisson regression was used to model the incidence rate ratios (IRR) of the number of hospital admissions while controlling for potential confounders. Predictive variables associated with the outcome variable in the bivariate analysis with a *P*-value < 0.20 were included in the multivariate analysis. The alpha level of 0.20 was chosen to reduce the likelihood of missing important predictors whose bivariate relationship with the outcome may be confounded with other variables.<sup>17</sup> In addition, it was determined a priori to include other variables expected to influence the number of hospital admissions due to asthma exacerbations in the multivariate analysis, such as age of the patient, level of depression, and degree of knowledge about asthma among mothers of included children. The goodness-of-fit of the Poisson regression models was assessed using Pearson's chi-squared statistic. All statistical tests were two-tailed, and the significance level used was *P* < 0.05. The data were analyzed with the Statistical Package Stata 12.0 (Stata Corporation, College Station, TX).

### RESULTS

Of the total number of children admitted to hospital due to asthma exacerbations during the study period (*n* = 119), 109 (91.5%) met our eligibility criteria and 101 (84.8%) were enrolled in the study. Of the eight excluded patients, three (37.5%), and two (25.0%) were excluded because gastroesophageal reflux disease and congenital heart disease were considered as the main cause of their respiratory symptoms, respectively. A total of three patients were not enrolled because their parents declined to complete the questionnaires. The median (IQR) age of the 101 patients included in the study was 5.5 (4.0–8.0) years. The age group distribution was: 35 (34.6%) <5 years, 60 (59.4%) between 5 and 12 years, and the remaining 5 (4.9%) between 13 and 18 years. Of the study participants, 61 (60.4%) were male and 40 (39.6%) were female. Regarding the number of hospital admissions due to asthma exacerbations in the year following admission to the study, 64 patients (63.4%) had

no hospital admissions, 28 patients (27.7%) had one hospital admission, four patients (4.0%) had two hospital admissions, and four patients (4.0%) had three or more hospital admissions due to asthma exacerbations in the year following admission to the study. Upon analyzing the data with respect to the degree of knowledge about asthma and depression among mothers of included children, the mean (standard deviation—SD) of the questionnaire covering knowledge about asthma was 44.02 (14.7), and the mean (SD) of the ZSDS was 37.08 (8.9). Based on the ZDS score, 90 (89.1%) of the mothers were classified as having no depression, and 11 (10.8%) were classified as having mild depression. No mothers were classified as having moderate or severe depression.

Detailed frequencies of exposures in patients both with and without hospital admissions due to asthma exacerbations in the year following admission to the study are shown in Table 1. The majority of these associations are self-explanatory; however, some deserve special attention. While dog ownership in the previous 12 months was the only variable significantly associated with hospital admissions in the year following admission to the study, maternal allergic rhinitis, maternal smoking, number of oral steroids bursts, and number of visits to the ED due to asthma exacerbation in the previous 6 months were all nearly significant. No statistically significant differences in age of the patients, total score of the ZSDS, or total score of asthma knowledge questionnaire were found between participants with and without hospital admissions in the year following admission to the study (Table 1).

After controlling for the age of the patients, dog ownership in the previous 12 months, number of oral steroids bursts prescribed due to asthma exacerbations in the previous 6 months, number of hospital admissions due to asthma exacerbations in the previous 6 months, doctor-diagnosed maternal allergic rhinitis, higher level of maternal education, total score of the ZSDS, and total score of the questionnaire about knowledge of asthma, we found that maternal smoking (IRR, 3.12; 95% confidence interval [95% CI], 1.12–8.68; *P* = 0.029) was the only independent predictor of hospital admissions due to asthma exacerbations in the year following admission to the study in our sample of patients (Table 2). The goodness-of-fit chi-squared test of the final Poisson regression model was not statistically significant (*P* = 0.425).

### DISCUSSION

The present study shows that in a population of asthmatic Latino children admitted to hospital for an asthma exacerbation, approximately one-third of the patients had at least one asthma exacerbation requiring hospital admission during the following year, and maternal smoking was the only independent predictor of these hospital admissions for asthma exacerbations.

**TABLE 1—Demographic Characteristics and Asthma-Related Variables of the Patients Included in the Study, According to Hospital Admissions in the Next Year Following the Admission to the Study**

Variable	Patients with hospital admissions (n = 36)	Patients with no hospital admissions (n = 65)	P value
Age [years; median (interquartile range—IQR)]	6.0 (4.0–8.0)	5.0 (4.0–8.0)	0.83
Gender, M/F	19/17	42/23	0.24
Allergic rhinitis	31 (86.1%)	57 (87.7%)	0.82
Higher level of maternal education			
Primary	4 (11.4%)	6 (9.2%)	0.74
Secondary	21 (60.0%)	32 (49.2%)	0.38
College, university, or higher	10 (28.6%)	27 (41.5%)	0.17
Higher level of paternal education			
Primary	5 (15.2%)	5 (7.7%)	0.32
Secondary	15 (45.5%)	32 (49.2%)	0.46
College, university, or higher	13 (39.4%)	28 (43.1%)	0.49
Maternal asthma	6 (16.7%)	9 (14.1%)	0.73
Paternal asthma	5 (13.9%)	8 (12.3%)	0.82
Maternal allergic rhinitis	12 (33.3%)	11 (16.9%)	0.06
Paternal allergic rhinitis	7 (19.4%)	11 (16.9%)	0.75
Maternal smoking	6 (17.1%)	3 (4.6%)	0.06
Paternal smoking	11 (31.4%)	13 (20.0%)	0.20
Dog ownership in the previous 12 months	5 (13.9%)	23 (35.4%)	0.02
Cat ownership in the previous 12 months	3 (8.3%)	3 (4.6%)	0.66
Number of oral steroids bursts <sup>1</sup>	1.0 (0–2.0)	0 (0–1.0)	0.07
Number of visits to the emergency department <sup>1</sup>	1.0 (0–2.75)	1.0 (1.0–2.0)	0.28
Number of hospital admissions <sup>1</sup>	1.0 (1.0–2.0)	1.0 (1.0–1.0)	0.07
Score of the ZSDS; mean (SD)	37.58 (7.21)	36.85 (9.72)	0.77
Score of asthma knowledge questionnaire	57.74 (5.18)	55.98 (6.73)	0.19

ZSDS, Zung-Self Rating Depression Scale.

<sup>1</sup>In the previous 6 months.

The present findings could have important consequences for predicting hospital admissions for asthma exacerbations in asthmatic Latino children, due to the fact that to our knowledge this is the first study done among asthmatic Latino children searching for prospective predictors of asthma hospitalization without any intervention (real world study). Moreover, since the only independent predictor of asthma hospitalizations found in

this study is a potentially modifiable risk factor, our results permit hypothesizing that interventions aimed at decreasing maternal smoking could decrease the probability of hospital admission for asthma exacerbations in asthmatic Latino children.

This harmful effect of maternal smoking on the respiratory system of children is supported by several pathophysiological mechanisms, such as the slowing of

**TABLE 2—Predictors of Number of Hospital Admissions Due to Asthma Exacerbations in the Next Year Following the Admission to the Study, in Multivariate Analysis**

Variable	Incidence rate ratios (IRR) (95% CI)	P value
Age	1.08 (0.39–3.03)	0.87
Dog ownership in the previous 12 months	1.29 (0.45–3.70)	0.63
Number of oral steroids bursts <sup>1</sup>	1.09 (0.72–1.64)	0.67
Number of hospital admissions <sup>1</sup>	1.18 (0.58–2.41)	0.63
Maternal allergic rhinitis	0.74 (0.30–1.81)	0.51
Higher level of maternal education		
Primary	1	—
Secondary	3.44 (0.32–36.84)	0.31
College, university, or higher	1.82 (0.15–21.31)	0.63
Score of the ZSDS	0.98 (0.94–1.03)	0.57
Score of asthma knowledge questionnaire	1.02 (0.96–1.09)	0.40
Maternal smoking	3.12 (1.12–8.68)	0.029

ZSDS, Zung-Self Rating Depression Scale.

<sup>1</sup>In the previous 6 months.

the beating of the cilia, destruction of respiratory cilia, decrease in the efficacy of clearing mucus from the airways, impairment of lung defenses, increase in epithelial permeability, recruitment of inflammatory cells, increase in neutrophilic inflammation, allergic sensitization, increase in the oxidative injury, increase in the oxidative metabolism of affected cells, and poor response to corticosteroid treatment.<sup>18</sup> In agreement with our findings, Gürkan et al.<sup>19</sup> in 140 Turkish children (aged 3–15 years.) reported that only maternal smoking (OR = 3.3) and age <5 years. remained as risk factors for asthma admission (but not atopy, maternal asthma, age, or inhaled corticosteroid use during the 48 months of follow-up). Also, in a case–control study on 124 Portuguese children (aged 1–10 years.) tobacco exposure was an independent risk factor for asthma hospitalization (OR = 6.6); atopy, maternal asthma, prior asthma hospitalization, and early onset of asthma were also risk factors.<sup>20</sup> However, neither maternal depression nor knowledge about asthma was investigated in either study. A study done in 115 American children (aged 4–18 years.) followed up for 1 year after asthma index hospitalization reported that caretaker characteristics (low sense of mastery, being less emotionally bothered by asthma) predicted greater likelihood of future asthma hospitalizations (after controlling for baseline asthma symptoms and medications); however, tobacco exposure was not analyzed.<sup>21</sup>

Recently, a study done on a group of Puerto Ricans (n = 678) reported that maternal depressive symptoms were associated with an increased risk of asthma hospitalizations at age 1 year; at age 3 years, maternal depressive symptoms were associated with asthma diagnosis and hospitalizations for asthma; and in an analysis combining 1- and 3-year outcomes, paternal depression was associated with oral steroid use, maternal depressive symptoms were associated with asthma hospitalizations and asthma diagnosis, and parental depression was associated with hospitalizations for asthma.<sup>22</sup> However, unlike our study, that study measured depression severity in parents of twins and patients aged <12 months at baseline, which could explain the higher prevalence of depression in parents and could have increased the probability of finding associations between parental depression and adverse asthma outcomes in their children.<sup>23</sup> A case–control study in the Bronx area in New York (n = 498) reported that a history of asthma hospitalizations within the past 12 months was an independent predictor of early readmission, but modifiable factors such as medical treatment and management during and upon discharge from the index admission did not predict early asthma readmission.<sup>24</sup> When we analyzed the asthma severity characteristics of our population (e.g., number of oral steroids bursts or ED visits or hospital admission in the previous 6 months), none of those remained as risk factors for future asthma

hospitalizations. However, unfortunately we did not evaluate the adherence rate to prescribed medications after discharge from hospital. In contrast, a multicenter study done in France, among 498 children (age 3–17 year) hospitalized for asthma, 66% had been consistently poorly controlled during the previous year, and the majority of them had at least one of the following preventable risk factors for hospitalization: no regular controller treatment, no asthma action plan, or no follow-up for asthma.<sup>25</sup> A Brazilian retrospective cohort study reported a rate of hospitalization of 5.2% among 151 asthmatic schoolchildren during 1 year of follow-up, and after analyzing asthma severity, level of maternal education, family income, peak expiratory flow (PEF), nutritional status, and parental history of asthma or rhinitis, asthma severity remained as the only variable that predicted these hospitalizations for asthma.<sup>26</sup> A recent Turkish study reported that only attack severity was a risk factor for asthma hospitalization, but not demographic or prophylactic asthma treatments.<sup>27</sup> Finally, in a population-based unselected birth cohort of 1,037 New Zealanders followed up to 26 years of age, 6.2% of participants experienced an asthma hospitalization (highest during the first 9 years. of age but continued until early adulthood), and the risk factors for these asthma hospitalizations were male gender, earlier ages of onset of symptoms, atopy, high AHR to methacholine, and lower lung function.<sup>28</sup> Reasons for all these different risk factors are not clear, but may be explained, at least in part, by differences in environmental exposure, population characteristics (ethnicity, insurance, crowding families, etc.), and inherent asthma severity and asthma management/treatment.

The main limitations of the present study are that we relied on self-reported smoking status without obtaining biochemical verification, the lack of assessment of adherence rate to inhaled corticosteroids prescribed at discharge from hospital, and the fact that the sample size was not large and was generated from one hospital using a non-probability sampling technique. Although self-reports can be subject to social desirability bias that can underestimate the real number of parent smokers, our results are consistent with findings in other previous studies that have validated the smoking status with cotinine measurement, suggesting that the smoking status determined in our study might not be so far from the real smoking status of the parents. Additionally, although parental smoking itself may explain the increased risk of asthma exacerbations in children, it is possible that this smoking status could be a surrogate marker of unmeasured lifestyle factors that are associated with a greater possibility for hospital admissions for asthma exacerbations, such as low adherence to prescribed medications, late access to health services, and an inadequate perception of the severity of the their children's disease.

With respect to sample size, although the sample size was not large, this sample size provided adequate power for conducting robust bivariate and multivariate analysis. Finally, the fact that the study was conducted in a single third-level hospital and used a non-probability sampling technique could limit the possibility of generalizing the results to the entire population of pediatric asthmatic patients living in LMIC, so further studies must be conducted in other contexts and using probability sampling techniques. The main strengths of this study are its prospective follow-up and the incorporation of measures of parental knowledge about asthma and maternal depression level, factors that have not been accounted for in many previous studies.

In conclusion, the present study shows that in a population of asthmatic Latino children admitted to hospital for an asthma exacerbation, approximately one-third of the patients had at least one asthma exacerbation requiring hospital admission the following year, and maternal smoking was the only independent predictor of these hospital admissions for asthma exacerbations. These findings should be considered preliminary and need to be confirmed by further studies performed with a more representative sample of asthmatic patients, obtaining biochemical verification of the smoking status of the parents and assessing the adherence rate to inhaled corticosteroids. Furthermore, if these results are replicated, future studies could be designed to assess whether interventions aimed to decrease maternal smoking are helping to lower the probability of hospital admission for asthma exacerbations in asthmatic Latino children.

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