

Factors associated with length of stay for pediatric asthma hospitalizations*

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Abstract

Objective: Asthma is a leading cause of pediatric hospitalizations, but little is known about factors associated with length of stay (LOS) for asthma hospitalizations. The aim of this study was to identify factors associated with LOS for pediatric asthma hospitalizations. **Methods:** The Pediatric Health Information System (PHIS) was used to cohort patients 2–17 years old with a primary asthma diagnosis discharged from 42 PHIS hospitals in 2011. Sociodemographic, temporal and health-status factors were examined. Bivariate and generalized-estimating-equation logistic regression analyses were performed to identify factors associated with LOS, after adjusting for severity of illness (SOI). **Results:** In total, 25 900 children were hospitalized, with a mean LOS of 1.9 days. In bivariate analysis, mean LOS was longer ($p < 0.01$) for patients with complex chronic conditions (CCC) (3.1 days versus 1.8 for non-CCC) and adolescents (2.3 versus 1.8 for 2–5 years old). In multivariable analysis, obstructive sleep apnea (OSA; OR 2.3; 95% CI: 1.8–2.9), older age (OR 1.3; 95% CI: 1.2–1.4), obesity (OR 1.3; 95% CI: 1.1–1.4), CCC (OR 1.3; 95% CI: 1.1–1.4), winter admissions (OR 1.2; 95% CI: 1.1–1.4), female gender (OR 1.1; 95% CI: 1.1–1.3), and weekend admissions (OR 1.1; 95% CI: 1.03–1.2) had higher odds of asthma LOS >2 days. **Conclusions:** OSA, older age, obesity, CCC, winter and weekend admissions, and female gender are associated with longer LOS for pediatric asthma hospitalizations, after adjustment for SOI. The study findings suggest that interventions focused on these at-risk groups may prove most useful in reducing LOS for pediatric asthma hospitalizations.

Keywords

Asthma hospitalization, diatric, hospitalized child, length of stay

History

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Introduction

Asthma is the most common pediatric chronic health condition in the US, affecting one in 11 children [1]. Pediatric asthma annually is responsible for more than 265 000 hospitalizations, at an estimated cost of nearly \$1 billion [2]. Asthma is the leading cause of hospitalizations and hospital costs in the nation for children 2–10 years old [2]. The median length of stay (LOS) for pediatric asthma hospitalizations has remained relatively unchanged for 20 years, despite advances in medical care, including the use of oral and inhaled corticosteroids and national guidelines for asthma management [3]. Due to the large volume of pediatric asthma hospitalizations, even small reductions in LOS can substantially diminish the economic burden. For example, the median LOS for children hospitalized with asthma is 2 days; a reduction of 0.5 days in median LOS, therefore, could result in over \$160 million in annual savings [2].

LOS frequently is used as a measure of care efficiency and efficacy, as well as a proxy for resource utilization [4];

however, little is known about the determinants of LOS. Limitations of previous research on asthma LOS in children include few exclusively pediatric studies with LOS as the primary focus; more commonly, LOS is a secondary outcome. Previous studies also often did not adjust for severity of illness (SOI). Furthermore, temporal factors, such as weekend versus weekday admissions, are not well-studied, and little is known about the impact of asthma co-morbidities, such as obesity, on LOS, outside of the intensive-care setting.

Given the large number of pediatric asthma hospitalizations, the frequent use of LOS as a quality metric, and limited prior research on asthma LOS in children, the primary goal of this study was to identify sociodemographic, temporal, health-status and hospital characteristics associated with LOS for pediatric asthma hospitalizations, after adjusting for SOI, in efforts to improve care delivery to children hospitalized with asthma. The secondary goal was to assess the utility of LOS as a quality metric for pediatric asthma hospitalizations.

Methods

Data source

The study design was a retrospective cohort using the Pediatric Health Information System (PHIS) database, which contains data from 44 US children's hospitals' medical records and billing systems. These hospitals are affiliated

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with the Children's Hospital Association (Overland Park, KS). Data quality and reliability are assured through a joint effort between the Children's Hospital Association and participating hospitals. The data warehouse function for the PHIS database is managed by Truven Health Analytics (Ann Arbor, MI). For the purposes of external benchmarking, participating hospitals provide discharge/encounter data, including demographics, diagnoses and procedures. Forty-two of these hospitals also submit resource utilization data (e.g. pharmaceuticals, imaging and laboratory) to PHIS. Data are de-identified at the time of submission, and subjected to a number of reliability and validity checks before inclusion in the database. For this study, data from the 42 hospitals submitting resource utilization data were included [5].

Study period and eligibility

The study period was 1 January 2011 through 31 December 2011. Inclusion criteria were: (1) children 2–17 years old; (2) a primary diagnosis of asthma, as defined by International Classification of Diseases (ICD9) codes 493.0–493.92; and (3) inpatient or observation status at the time of discharge. Exclusion criteria were: (1) children <2 years old, due to the potential overlap between wheezing from lower respiratory tract infections and a true diagnosis of asthma; and (2) children >17 years old, due to varying inpatient practices among hospitals for this age range.

Variables

LOS was the primary outcome, defined as the total number of days from admission to discharge date. LOS is measured in the PHIS database as the number of midnights a patient stays in the hospital. A patient admitted and discharged on the same day has a LOS equal to one day. Independent variables included sociodemographic, temporal and health-status characteristics. Sociodemographic characteristics consisted of age, gender, race/ethnicity and insurance coverage. Temporal characteristics included the admission month, weekend (defined as Friday through Sunday) versus weekday admission day, and admission season, based on meteorological seasons.

SOI was defined using the 3M All-Patient-Refined Diagnosis-Related Groups (APR-DRG) methodology as “the extent of physiologic decompensation of organ system loss of function”. APR-DRGs are a joint development of 3M Health Information Systems and the National Association of Children's Hospitals and Related Institutions. APR-DRGs were developed through an iterative process of formulating clinical hypotheses and then testing the hypotheses with historical data. An expert panel of clinicians from various specialties reviewed all logic for clinical accuracy. The detailed overview of the logic of the APR-DRGs is available publicly elsewhere [6].

Additional health-status characteristics included whether a patient had an intensive-care unit (ICU) stay, needed mechanical ventilation or extracorporeal membrane oxygenation, had a complex chronic condition [7] (Appendix Table A1), or had an asthma co-morbidity. Asthma co-morbidities were defined as the presence of a secondary diagnosis of obesity, allergic rhinitis, gastroesophageal reflux (GER) and/or

obstructive sleep apnea (OSA), as determined by ICD coding. Hospital characteristics comprised of the regional location of the hospital and the number of asthma cases seen per year. Regional location of hospitals was determined using the US Census Bureau geographic regions, as West, Midwest, South or Northeast [8].

Analyses

Bivariate analyses were performed to examine associations between the independent variables and LOS, using two-tailed *t*-tests for continuous variables and χ^2 tests for categorical variables. Generalized-estimating-equation (GEE) logistic-regression analysis was used to adjust for any potential clustering by hospital. All variables either significantly associated with LOS in the bivariate analyses or associated previously with LOS (i.e. season and weekend admission) were included as initial candidate variables in the procedure. The initial α -to-enter was set at 0.15, and $p < 0.05$ was considered to be statistically significant for final inclusion or withdrawal from the model. GEE logistic regression analysis was used to obtain adjusted odds ratios and 95% confidence intervals for factors associated with a LOS > 2 days. LOS was dichotomized as ≤ 2 versus >2 days, based on the median LOS for pediatric asthma hospitalizations in previous work [3].

Results

There were 25 900 asthma admissions to the 42 study hospitals in 2011. More than 90% of the asthma admissions were for children <13 years old, and over 60% were for males (Table 1). African-Americans comprised 47% of the admissions, followed by non-Latino whites, at 27%, and Latinos, at 17%. Sixty percent of admitted children were insured through Medicaid, followed by 17% through private insurance and 10% through health maintenance organizations. Children with complex chronic conditions comprised 7% of asthma admissions; each of the specific co-morbid conditions comprised <5% of admissions. Sixty-five percent of hospitals were located in the South or Midwest. The median number of asthma cases per hospital was 526, with a range of 123–2359. Thirty-four percent of children were admitted in the fall, 25% of children in the spring or winter and only 14% in the summer. More than 40% of children were admitted on the weekend.

Bivariate analyses

Sociodemographic characteristics

The mean LOS for all asthma admissions was 1.9 days ($SE \pm 0.01$; Table 2). Adolescents (13–17 years old) were significantly more likely to have a longer LOS than younger children. Children with complex chronic conditions had a LOS more than 1 day longer than children without complex chronic conditions. Each asthma co-morbidity was associated with a longer LOS, except for allergic rhinitis. Children with OSA had a mean LOS of more than 1.5 days longer than children without OSA. Children with GER had a mean LOS of more than 1 day longer than children without GER. The mean LOS for obese children was more than one-half day longer than non-obese children. Public insurance, male

Table 1. Selected characteristics of study children admitted for asthma ($n = 25\,900$).

Characteristics	Proportion
Age ^a	
2–4 years old	40.7%
5–12 years old	50.1%
13–17 years old	9.2%
Gender	
Male	61.9%
Female	38.1%
Race/Ethnicity	
African-American ^b	47.4%
White ^b	27.2%
Latino	17.3%
Asian/Pacific Islander	2.1%
American Indian	0.3%
Other	5.9%
Insurance	
Medicaid	60.5%
Private	17.3%
Health maintenance organization (HMO)	10.4%
Other	8.5%
None	3.4%
Complex chronic condition	6.6%
Co-morbidity	
Gastroesophageal reflux	4.0%
Obesity	3.9%
Allergic rhinitis	2.7%
Obstructive sleep apnea	1.4%
Regional location of hospital ^c	
South	39.1%
Midwest	26.5%
Northeast	19.1%
West	15.3%
Total asthma cases per hospital above median (Median = 526 cases/year)	48.1%
Admit season	
Fall	34.3%
Winter	25.1%
Spring	26.9%
Summer	13.7%
Admit day	
Weekday	58.8%
Weekend	41.2%

^aBased on American Academy of Pediatrics age-group categories for early childhood, late childhood and adolescence.

^bNon-Latino African-American and Non-Latino white, respectively.

^cBased on 2010 U.S. Census Bureau geographic regions.

gender and “other” race/ethnicity also were associated with a slightly longer LOS.

Regional and temporal characteristics

Children hospitalized for asthma in hospitals located in the West had a slightly longer LOS, but not clinically significant, than those hospitalized in the South. Compared with summer asthma admissions, winter admissions were associated with a somewhat longer LOS, but there were no LOS differences between weekday and weekend admissions in bivariate analysis (Table 2).

Multivariable analyses

After adjusting for SOI, several factors were significantly associated with a pediatric asthma hospitalization LOS of greater than 2 days (Table 3). Children with OSA had more

Table 2. Bivariate analysis of characteristics associated with length of stay for pediatric asthma hospitalizations ($n = 25\,900$).

Characteristics	Mean length of stay (days)	<i>p</i>
All asthma admissions ($\pm$ SE)	1.9 ($\pm$ 0.01)	–
Age		
13–17 years old	2.3	<0.01
5–12 years old	1.9	
2–4 years old	1.8	
Complex chronic condition		<0.01
Present	3.1	
Absent	1.8	
Asthma co-morbidity		
Obstructive sleep apnea	3.5	<0.01
No obstructive sleep apnea	1.9	
Gastroesophageal reflux	3.1	<0.01
No gastroesophageal reflux	1.9	
Obesity	2.5	<0.01
No obesity	1.9	
Allergic rhinitis	1.8	0.25
No allergic rhinitis	1.9	
Insurance		<0.1
Public	2.0	
Private	1.9	
Other	1.9	
None	1.9	
HMO	1.8	
Gender		<0.01
Male	2.0	
Female	1.9	
Race/ethnicity		0.02
Other	2.0	
White	1.9	
African-American	1.9	
Latino	1.9	
Asian/Pacific Islander	1.9	
American Indian	1.9	
Regional location of hospital		<0.01
West	1.99	
Midwest	1.91	
Northeast	1.91	
South	1.90	
Admission season		<0.01
Winter	2.0	
Spring	1.9	
Fall	1.9	
Summer	1.8	
Total asthma cases per hospital		0.46
Above median ^a	1.9	
Below median	1.9	
Admission day		0.51
Weekday	1.9	
Weekend	1.9	

^aMedian = 526 cases/year.

than two times the odds of a longer hospitalization. Older children, obese children, children with complex chronic conditions, and females also had greater odds of a longer hospitalization. Winter and weekend admissions additionally were associated with greater odds of prolonged LOS, whereas summer admissions were associated with decreased odds of prolonged LOS.

Discussion

Children with OSA were found to have more than doubled the odds of a prolonged LOS for asthma hospitalizations, with a mean LOS almost 2 days longer than for children without OSA. Recent studies show an increased prevalence of OSA in

Table 3. Generalized-estimating-equation logistic-regression analysis of characteristics associated with a length of stay >2 days for pediatric asthma hospitalizations.

Characteristics	Odds ratio (95% confidence interval) of LOS >2 days ^a
Obstructive sleep apnea	2.3 (1.8, 2.9)
Complex chronic condition	1.3 (1.1, 1.4)
Obesity	1.3 (1.1, 1.6)
Age ^b	1.3 (1.2, 1.4)
Female gender	1.1 (1.1, 1.2)
Weekend admission	1.1 (1.03, 1.2)
Other race/ethnicity ^c	1.1 (0.99, 1.3)
African-American	0.99 (0.8, 1.2)
Latino	0.99 (0.9, 1.3)
Winter admission ^d	1.2 (1.1, 1.4)
Fall admission ^d	0.9 (0.9, 1.04)
Summer admission ^d	0.9 (0.8, 0.9)
West region	1.03 (0.7, 1.6)
Midwest region	1.03 (0.7, 1.6)
South region	0.99 (0.8, 1.3)

Bolded values are statistically significant.

^aAdjusted for severity of illness.

^bAssessed as a continuous variable.

^cReferent = white; Asian/Pacific Islander and American Indian were grouped into the “other” race/ethnicity group, due to limited sample sizes.

individuals with asthma [9–11]. In adults, research suggests that patients with both OSA and asthma are vulnerable to nocturnal rapid-eye-movement (REM) sleep cycle-related abnormalities, including hypoxemia and hypoventilation. It has been hypothesized that decreased accessory respiratory muscle tone during REM sleep leads to reduced pulmonary reserve, and subsequently, to increased hypoxemia and hypoventilation [12,13]. Recently, a similar association of increased vulnerability to hypoxemia during REM sleep in children with OSA and asthma has been described [14]. These findings suggest that children with OSA and asthma may experience greater severity of nocturnal hypoxemia and hypoventilation, and, perhaps, when hospitalized, might take longer to return to their baseline respiratory status. OSA therapies, such as adenotonsillectomy and continuous positive airway pressure, have been found to improve asthma symptoms, peak expiratory flow rates and disease severity [15,16], and may prove useful in reducing hospital LOS for hospitalized children with OSA and asthma. Alternatively, the baseline nocturnal saturation of these children may not be known, and as such, they may be managed more conservatively, including administration of bronchodilators or oxygen support, due to the presence of overnight desaturations that may be within their baseline range. An understanding of the baseline nocturnal desaturation level for children with OSA and asthma may be useful in determining appropriate hospital management.

Adolescents also were found to have increased odds of prolonged LOS for asthma hospitalizations, with an average LOS of a half-day longer than for younger children. Non-adherence to asthma therapy and high-risk behaviors during adolescence may contribute to these findings. Previous research indicates that adolescents are particularly vulnerable to asthma therapy non-adherence and poor treatment outcomes [17,18]. Children with chronic diseases, such as asthma, often transition from parental management to

self-management of their disease during adolescence [19]. This transition requires physical, social, emotional and cognitive changes, and failure to adequately transition is associated with poor adherence [19]. In addition, high-risk behaviors, such as tobacco use, are common among adolescents with asthma, and are associated with medication non-adherence and poor outcomes [20]. No single intervention has been identified as optimal in improving asthma management for adolescents, but interventions focused on lifestyle factors, family-support mechanisms and education on controller medications are associated with improved care [21,22]. For adolescents hospitalized with asthma, thus, efforts focused on medication adherence, risk reduction, self-management, family support and medication education might have the potential to reduce LOS.

Obesity was associated with significantly greater odds of prolonged LOS, with a mean LOS that was more than a half day longer than for non-obese children. Growing evidence supports an association between obesity and asthma, including obesity as a risk factor for both developing asthma and for poor asthma control [23–25]. Our study results complement prior findings demonstrating longer ICU and hospital LOS for obese children with severe asthma exacerbations [26]. Limited research exists on interventions to improve health outcomes for obese children with asthma. A tailored combination of pharmacologic and non-pharmacologic therapies, including weight-loss and dietary interventions, has been suggested to optimize asthma therapy for obese patients [23]. In addition, a recent randomized, controlled trial in obese children with asthma suggests that diet-induced weight change can improve asthma control [27]. In turn, improved asthma control may improve the child's exercise tolerance and further contribute to weight-loss efforts. For obese children hospitalized with asthma, however, more studies are needed on interventions that might help reduce LOS.

Children with complex chronic conditions were found to have higher odds of prolonged LOS for asthma hospitalizations, averaging a LOS that was 1.3 days longer than for children without complex conditions. Children with complex chronic conditions account for an increasing proportion of inpatient pediatric hospitalizations, making up more than 10% of all hospitalizations for children [28,29]. Complex chronic conditions have been associated with overall increased resource utilization among children, including LOS [29]; however, the co-morbid impact of complex chronic conditions on children with asthma had not been studied. Although research is lacking on interventions to enhance care for children with complex chronic conditions, limited evidence supports hospitalist management or co-management, enhanced care coordination, use of clinical scores to predict deterioration and error-free medication reconciliation as potential means to optimize inpatient care for these children, and potentially reduce LOS [30–35].

After adjustment for SOI and other covariates, females were found to have somewhat higher odds than males of prolonged LOS. Gender differences in asthma prevalence are well-described; although asthma is more prevalent in pre-adolescent males, it has a higher prevalence among females during adolescence and adulthood [36,37]. Possible explanations for this gender-prevalence shift in asthma include

gender-specific differences in hormones, genetics, pulmonary mechanics and environmental exposures, such as diet, allergen exposure or cigarette smoking [36–39]. A prior study suggested that female gender also is significantly associated with higher rates of asthma hospitalizations during adolescence [40]; however, research on gender differences in LOS for children is limited. Adult studies have documented longer LOS for women hospitalized with asthma [41,42]. One pediatric study suggested that males are significantly more likely than females to have a hospital stay of <24 h [43]. Improved asthma control for adult females has been achieved by greater recognition and treatment of hormonal changes, including menstruation and pregnancy [44,45]. A greater understanding of gender differences in pediatric asthma hospitalizations may help identify effective interventions to reduce LOS for females.

Winter pediatric asthma hospitalizations are associated with increased odds of a prolonged LOS, consistent with studies on adult asthma admissions [42,46]. Several pediatric studies have described peaks in asthma hospitalization rates in winter, fall and spring [47–49]. Possible explanations for these seasonal peaks include increases in the prevalence of respiratory viruses, school-related exposures and increased allergen and pollution exposure [47–52]. Although seasonal differences in admission rates exist, to the best of our knowledge, seasonal differences in LOS for pediatric asthma hospitalizations have not been well described. Improved resource utilization, including the use of observation units, adequate staffing levels and sufficient bed availability, have been shown to decrease LOS during high-utilization periods [53–55], such as the winter season. More research is warranted to determine whether or not interventions might have the potential to address seasonal variation in pediatric asthma hospitalization LOS.

Weekend admissions were found to have somewhat higher odds of prolonged LOS for pediatric asthma hospitalizations. Commonly described as the “weekend effect”, weekend admissions have been associated with decreased quality of care in both adult and pediatric settings, including higher costs, increased medication error rates and longer LOS [56–58]. One study showed that the weekend hospital discharge rate was more than 50% lower, compared with reference rates, and teams that were post-call had 20% lower discharge rates [59]. Interventions that have been shown to improve weekend care quality and reduce LOS include ensuring intensity of inpatient care and reorganizing internal processes, such as attending schedules [59,60], and these might also prove useful in reducing LOS for pediatric asthma hospitalizations.

Limitations

Certain study limitations should be noted. The study was conducted using the PHIS database; the findings, therefore, are limited to the sociodemographic, temporal and health-status variables available in PHIS. Certain additional variables, including attending-physician presence, nighttime staffing patterns, and the presence of newly diagnosed versus chronic asthma, were unavailable in the PHIS database. The only available PHIS LOS unit is days, rather than the

actual time of admissions and discharges. In addition, the study did not assess readmission rates of these children. In contrast to adults with asthma, the 30-day all-cause readmission rate for children with asthma admitted to PHIS hospitals has previously been shown to be low, ranging from 3% to 9%, with no association between decreased LOS and increased readmissions [61]. PHIS reports patient race/ethnicity; however, variable practices across hospitals may exist in identifying race/ethnicity. The study included hospitals located across the nation; however, PHIS is not a nationally representative data source. The findings, thus, may not generalize to non-PHIS member hospitals. In addition, ICD-9 codes are dependent on the documentation of providers, and may therefore under or over-represent patient diagnoses.

Conclusions

Factors significantly associated with longer LOS for pediatric asthma hospitalizations include OSA, older age, obesity, complex chronic conditions, winter admission, weekend admission and female gender. Factors independent of SOI impact LOS, and the findings suggest that caution should be exercised when using LOS as a quality metric. Interventions focused on children with OSA, obesity and complex chronic conditions may prove most useful in reducing LOS for pediatric asthma hospitalizations. In addition, hospital-system interventions focusing on winter and weekend admissions also might be helpful in reducing LOS for pediatric asthma hospitalizations.

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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Appendix

Table A1. Categories of complex chronic conditions and associated diagnoses.

Complex chronic condition category	Diagnoses
Cardiovascular	Heart and great vessel malformations Cardiomyopathies Conduction disorders and dysrhythmias
Gastrointestinal	Congenital anomalies Chronic liver disease and cirrhosis Inflammatory bowel disease
Hematologic or immunologic	Sickle cell disease Hereditary anemias Hereditary immunodeficiency Human immunodeficiency virus disease
Metabolic	Amino acid metabolism Carbohydrate metabolism Lipid metabolism Storage disorders Other metabolic disorders
Neuromuscular	Brain and spinal cord malformations Mental retardation Central nervous system degeneration and disease Infantile cerebral palsy Epilepsy Muscular dystrophies and myopathies
Other congenital or genetic defect	Chromosomal anomalies Bone and joint anomalies Diaphragm and abdominal wall Other congenital anomalies
Respiratory	Respiratory malformations Chronic respiratory disease Cystic fibrosis