Published in final edited form as:

J Asthma. 2016 February ; 53(1): 15–18. doi:10.3109/02770903.2015.1081940.

Temporal trends and factors associated with hospital admission with a respiratory infection in children

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Abstract

Objectives—Asthma is the leading cause of emergency room visits in children, and those with asthma tend to suffer from more severe consequences of respiratory tract infections. The aims of this study were among children who required hospitalization, compare differences between those admitted with or without respiratory infection, describe changes in yearly proportion of asthma among the children admitted with a respiratory infection in New York City from 2006 to 2012, and ascertain how asthma affected the average length of hospital stay for those with respiratory infection.

Methods—We conducted an historical prospective study using data obtained from multiple electronic sources of patients discharged from a 200 bed pediatric hospital in a major metropolitan healthcare system between 2006 and 2012. Patient characteristics were obtained from electronic health records and billing codes.

Results—Among 83,348 patient discharges, there were 5,057 (6.1%) with a respiratory infection. In the multivariable model, children with the following characteristics were significantly more likely to be admitted with a respiratory infection as compared with other diagnoses: asthma [odds ratio (OR) 4.68 (95% confidence limits (CL): 4.31, 5.08], male sex [OR:1.11 (1.05, 1.18)], prior hospitalization [OR: 3.65 (3.43, 3.89)], renal failure [(OR: 2.14 (1.70, 2.70)], and Medicaid coverage [OR: 1.93 (1.81, 2.05)]. Children age 5 years (OR: 0.44 (0.41, 0.47) and those with diabetes (OR: 0.32 (0.21, 0.51) were less likely to be admitted with a respiratory infection. Hospitalized patients with respiratory infection and asthma, identified by ICD-9 codes, had significantly shorter lengths of stay than patients without asthma, 5.3 and 9.0 days, respectively, $p < 0.001$. Asthma in patients admitted with a respiratory infection increased from 19.2% in 2006 to 28.2% in 2012, peaking at 34.1% in 2010 ($p < 0.001$).

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Declaration of Interest

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

Conclusion—This study suggests that asthma is a significant risk factor for hospitalization of children with respiratory infection, and suggests that the prevalence of asthma is increasing over time among children hospitalized with respiratory infection in this urban setting.

Keywords

respiratory syncytial virus; pneumonia; influenza; acute bronchitis and bronchiolitis; rhinovirus; human metapneumovirus; asthma

INTRODUCTION

Asthma is a major cause of disability worldwide, and accounts for considerable healthcare costs and loss of work productivity [1]. With its high economic burden, it is considered a disease of major public health importance by the World Health Organization [2]. The Global Initiative for Asthma estimated that 300 million people worldwide had asthma in 2004, and projected that this number would increase to 400 million by 2025 as countries became more urbanized [3]. The link between respiratory tract infections and acute asthma exacerbation has been recognized and well documented [2, 4]. Those with asthma tend to suffer from more severe consequences of respiratory tract infections [5], including influenza, rhinovirus (RV), and respiratory syncytial virus (RSV) [4].

Asthma is the most common chronic disease of childhood and a leading cause of emergency room visits, hospitalizations, and missed school days, especially in New York City's poorest neighborhoods [3, 6]. According to the Centers for Disease Control and Prevention (CDC), approximately 7.4 percent of New Yorkers under 18 years of age, or about 315,000 children, had asthma in 2010 [7]. In the same year, about 7,400 children in New York City had cases that were serious enough that they needed to be hospitalized [8]. The urban environment has a number of factors that could have adverse effects on children's respiratory health [9]. Understanding the relationship between respiratory infections and asthma in children living in large urban areas can help improve effective prevention efforts for children with asthma in an urban setting. We hypothesized that among children admitted to the hospital there would be a higher proportion of asthmatics among those with an admission diagnosis of respiratory infection when compared with children admitted to the hospital with other diagnoses. As such, the aims of this study were, among children who required hospitalization in New York City from 2006 to 2012, (1) compare differences between those admitted with or without respiratory infection, (2) describe changes in yearly proportion of asthma, and (3) ascertain how asthma affected the average length of hospital stay for those with respiratory infection.

METHODS

Sample and setting

Data were collected from the records of children admitted to an approximately 200 bed pediatric hospital between 2006–2012 within the New York-Presbyterian Hospital (NYPH) System, the largest healthcare system in metropolitan New York City. This study was approved by the Institutional Review Board of Columbia University Medical Center.

Data collection

Electronic data were extracted as described previously [10] from the admission, discharge, transfer (ADT) and billing system, the clinical data warehouse, and the electronic health records of the pediatric hospital. A database was created using administrative records including age, admission and discharge dates, and previous hospitalizations within the system; and *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* diagnosis and procedure codes with codes for diagnoses present on admission, admission source, and discharge diagnoses [10].

Measures

Respiratory infections were defined by ICD-9 codes and included RSV infection, pneumonia, influenza, acute bronchitis and bronchiolitis, RV, human metapneumovirus (hMPV), and other diseases of the respiratory system, including acute lower respiratory tract infection present on admission. The main predictor was a dichotomized variable indicating whether the patient had asthma present on admission as defined by ICD-9 code. Patient demographic characteristics, including sex (male/female), age (<5 and ≥5 years), and insurance (Medicaid/not Medicaid) were also collected as well as data on previous hospitalizations within the network (yes/no). We dichotomized age (<5 and ≥5 years) since most children develop their first symptoms of asthma before they reach the age of 5 years (<http://www.aaaai.org/patients/publicedmat/tips/childhoodasthma.stm>. Accessed Jul 3, 2015). We also collected data on chronic conditions at the time of hospital admission including diabetes mellitus, renal failure, malignancies, dialysis, and transplant (yes/no), and the Charlson Comorbidity Index, which is a cumulative weighted index to identify the seriousness and risk of death associated with a number of co-morbid conditions. It includes >20 factors such as age, serum albumin, malignancies, liver disease, heart failure, etc. [11].

Statistical analyses

We determined the bivariate associations between respiratory infection and asthma, as well as other controlling variables such as sex, age, insurance, prior hospitalization, comorbidities, and the Charlson Comorbidity Index. Chi square tests were used for categorical data and Student's t-tests for normally distributed data or Mann-Whitney tests as appropriate were used for continuous variables. In these analyses the primary outcome of interest was admission with respiratory infection (yes/no) and the main predictor variable of interest was asthma (yes/no). All variables significantly associated with respiratory infection were included in a multivariable logistic regression model. To assess differences in length of stay between children admitted with or without asthma, controlling for potential confounders, we used multiple linear regression analysis (general linear models). Finally, we evaluated changes in the yearly proportion of asthma in patients admitted with respiratory infection using the Cochran-Armitage test for trend. We set the p-value at $p = 0.01$ to minimize the potential for the large sample size to result in statistically but not clinically significant differences. All analyses were completed using SAS version 9.3 (SAS Institute Inc., Cary, NC).

RESULTS

A total of 83,348 patients were included in this analysis. During the seven-year study period there were 5057 pediatric patients (2258 girls, 44.7%, and 2799 boys, 55.4%) admitted to the study hospital with a diagnosis of respiratory infection. The mean age of all patients was 4.8 years (standard deviation (SD) 6.67 years): for non-infected patients: 4.9 years (SD 6.74) and infected patients, 3.7 years (SD 5.06), $p < 0.001$. Mean length of stay for all children was 7.12 days (SD: 14.04). Descriptive characteristics and results of the bivariate analyses are presented in Table 1. Among children admitted with a respiratory infection, a higher proportion had asthma (1191, 23.6%) than among patients admitted without a respiratory infection (4733, 6.1%, $p < 0.001$). Patients with a respiratory infection also had a higher Charlson Comorbidity Score than patients without a respiratory infection (0.58 and 0.35, respectively, $p < 0.001$).

In the multivariable model, boys, children with asthma, and those with prior hospitalization, renal failure and Medicaid coverage were significantly more likely to be admitted with a respiratory infection as compared with other diagnoses and children age 5 years and those with diabetes were less likely to be admitted with a respiratory infection (Table 2). Controlling for gender, age, insurance, prior hospitalization, diabetes, renal failure, and Charlson Comorbidity Score, children with respiratory infection who also had asthma had on average a shorter length of stay than those without asthma (5.3 (SD: 1.77) and 9.0 (SD: 1.70) days, respectively, $p < 0.001$). The proportion of children admitted with a respiratory infection who also had asthma increased from 19.2% in 2006 to 28.2% in 2012 ($p < 0.001$; Figure 1).

DISCUSSION

Consistent with other studies, asthma, male sex, age < 5 years, prior hospitalization, Medicaid coverage, and renal failure were significantly associated with increased risk of hospital admission for a respiratory infection [16–20]. As other studies have done, Medicaid coverage was used as a surrogate of socioeconomic status [12,13] because, with the exception of a few medical conditions, Medicaid coverage is offered to patients below the federal poverty level, and the majority of Medicaid beneficiaries have incomes below the poverty line [14,15].

In the multivariable model children with diabetes were less likely than those without diabetes to be admitted with a diagnosis respiratory infection even though infectious diseases like respiratory infection are more frequent in those with diabetes [21, 22]. Because we controlled for numbers and types of comorbidities, this finding is not likely due to differences in severity of illness but rather that diabetics were admitted for causes other than respiratory infection. While the increased prevalence of asthma in patients with respiratory infection over time was consistent with the CDC findings of a continued nationwide increase in asthma prevalence [23], the average length of stay for those with respiratory infection was shorter if patients had asthma as compared to patients who did not have asthma. Similarly, Stranges et al. [24] also reported that mean pediatric stays in the United States were significantly shorter for those with asthma compared to those without asthma. This could

mean the asthmatic patients admitted to this pediatric hospital had less severe infections, which would be contradictory to other study results [5], or that asthmatic children with respiratory infections are more likely to be admitted to the hospital as a precautionary measure.

While this is a large study, the research has limitations. There is the potential for misclassification as this study used ICD-9 codes to define respiratory infections and asthma, and other clinical risk factors and comorbidities were identified through electronic data sources which were not collected for research purposes. In addition, although the sample size was large, the study was restricted to one pediatric hospital within a single network, limiting generalizability, particularly beyond large urban settings.

This study provides further evidence that asthma is a risk factor for hospitalization due to respiratory infection. Consistent with other reports, we found that the average length of stay was shorter for asthmatics than non-asthmatics admitted with respiratory infection, and there appeared to be an increase over time in the proportion of children admitted to hospital with respiratory infection who have asthma.

Acknowledgments

This study was funded by The National Institute of Nursing Research ("Health Information Technology to Reduce Healthcare-Associated Infection: HIT-HAI), 2R01NR010822.

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Figure 1. Hospital admissions for respiratory infection among children with and without asthma by year, 2006–2012

Yearly change in proportion is significant using Cochran-Armitage test for trend ($p < 0.001$).

Table 1

Characteristics of patients with and without respiratory infection

Variable	Respiratory Infection (N=5057)	No Respiratory Infection (N=78291)	Total (N=83348)	Bivariate analysis p-value ^a
Gender				<0.001
Female (n (%))	2258(44.7)	38627 (49.3)	40885 (49.1)	
Male (n (%))	2799 (55.4)	39664 (50.7)	42463 (50.9)	
Age				<0.001
<5	3659 (72.4)	50972 (65.1)	54631 (65.5)	
5	1398 (27.6)	27319 (34.9)	28717 (34.5)	
Mean, years (SD)	3.73 (5.06)	4.93 (6.74)	4.84 (6.67)	
Asthma	1191 (23.6)	4733 (6.1)	5924 (7.1)	<0.001
Insurance				<0.001
Not Medicaid	1527 (30.2)	41271 (52.7)	42798 (51.4)	
Medicaid	3530 (69.8)	37020 (47.3)	40550 (48.6)	
Prior	3138 (62.1)	22863 (29.2)	26001 (31.2)	<0.001
Hospitalization				
Diabetes Mellitus	20 (0.4)	966 (1.2)	986 (1.2)	<0.001
Renal Failure	99 (2.0)	738 (0.9)	837 (1.0)	<0.001
Malignancy	203 (4.0)	3709 (4.7)	3912 (4.7)	0.02
Dialysis	15 (0.3)	132 (0.2)	147 (0.2)	0.04
Transplant	11 (0.2)	312 (0.4)	323 (0.4)	0.05
Mean (range)	0.58 (0–10)	0.35 (0–14)	0.36 (0–14)	<0.001 ^b
Charlson				
Comorbidity Index				
Mean (SD) length of stay (days)	8.13 (14.22)	7.07 (14.05)	7.12 (14.04)	<0.001

^a Chi-Square test unless otherwise denoted^b Wilcoxon-Mann-Whitney Test

SD: Standard deviation IQR: Interquartile range

Table 2

Factors associated with being admitted with a respiratory infection versus without a respiratory infection

Variable	Multivariate analysis Odds Ratio (95% CI)
Gender (reference, female)	1.11 (1.05, 1.18)
Age (reference, <5)	0.44 (0.41, 0.47)
Asthma	4.68 (4.31, 5.08)
Insurance (reference, Not Medicaid)	1.93 (1.81, 2.05)
Prior Hospitalization	3.65 (3.43, 3.89)
Diabetes Mellitus	0.32 (0.21, 0.51)
Renal Failure	2.14 (1.70, 2.70)
Charlson Comorbidity Index	0.97 (0.94, 1.00)