

Factors Associated With Asthma Diagnosis Within Five Years of a Bronchiolitis Hospitalization: A Retrospective Cohort Study in a High Asthma Prevalence Population

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OBJECTIVES: Bronchiolitis, the leading cause of infant hospitalizations in the United States, is associated with increased risk of childhood asthma. We hypothesized that factors during a bronchiolitis hospitalization were associated with subsequent asthma.

METHODS: This is a retrospective cohort study at an urban, tertiary-care children's hospital of infants <12 months old, hospitalized for bronchiolitis. The primary outcome measure was an asthma diagnosis, defined as a billing code for an asthma visit or a prescription for controller medication, within 5 years of discharge from the bronchiolitis hospitalization.

RESULTS: There were 534 infants hospitalized for bronchiolitis, of which 294 (55.1%) were diagnosed with asthma, and 102 (19.1%) were hospitalized for asthma within 5 years of discharge. There was significant interaction between age and family history. In both models, female sex was protective (odds ratio [OR] 0.46). Age and race were only associated with asthma in infants without a family history of asthma: age (OR 1.19; 95% confidence interval 1.08–1.32) and race (OR 4.06; 95% confidence interval 1.56–10.58). Hospitalization length, ICU stay, albuterol treatments received, supplemental oxygen, respiratory support, highest respiratory rate, and respiratory syncytial virus infection were not associated with asthma diagnosis.

CONCLUSIONS: More than 55% of infants hospitalized for bronchiolitis developed asthma within 5 years of discharge. Demographic and family history variables were independently associated with asthma. However, hospital-based variables during the bronchiolitis hospitalization were not independently associated with asthma. These results can direct further research and differentiate anticipatory guidance for infants with bronchiolitis at risk for asthma.

ABSTRACT

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Bronchiolitis is the leading cause for infant hospitalization <12 months of age, accounting for >100 000 admissions annually in the United States.¹ Infants presenting with bronchiolitis are typically <24 months of age and display respiratory distress, upper and lower airway mucous obstruction, and wheeze. Infants exhibiting severe symptoms may require hospitalization. Bronchiolitis is most commonly caused by respiratory syncytial virus (RSV) but can also be caused by other viral infections.²

It is indicated in existing studies that 22% to 48% of infants hospitalized for bronchiolitis will develop childhood asthma.³⁻⁶ Asthma, a chronic lung disease caused by bronchoconstriction and airway inflammation, is 1 of the top 5 conditions affecting children in the United States.⁷ Of these conditions, asthma ranks second in medical expenditures at \$9.3 billion in 2008.⁷

The patient population treated in our hospital has a much higher asthma prevalence than children nationwide, with 15.5% of children in our community having a diagnosis of asthma compared with 8.9% of all children in the United States.^{8,9} It is hypothesized that this high prevalence of asthma is related to the high rates of poverty and minority populations in our community because both poverty and minority status have been independently linked to asthma.¹⁰ Our hospital is located in 1 of the most diverse communities in the United States where 56% of the population identifies as Hispanic or Latino, 45% of the population identifies as white, and 44% of the population identifies as black.¹¹ Annually, Bronx, New York has 1 of the highest rates of hospital discharges for asthma (89 per 10 000 children), which is nearly 5 times the national average (18.3 per 10 000 children),^{12,13}

The association between bronchiolitis and asthma is confounded by certain risk factors, allowing further differentiation of patient populations that are at higher risk of developing asthma. Some of these factors include parental history of asthma,^{5,14-17} aeroallergen sensitization,^{5,15} male sex,^{15,18-20} dog allergen,⁵ human rhinovirus as the viral

etiology,²¹ smoking exposure,^{15,22} eosinophilia,²³⁻²⁵ and atopic dermatitis.^{14,17} A retrospective study revealed that increased severity of bronchiolitis (outpatient treatment versus emergency department [ED] visit versus hospitalization) was associated with higher subsequent rates of asthma, revealing a severity-dependent relationship between the initial bronchiolitis episode and later development of asthma.⁶ Few studies have been used to examine whether clinical variables during the bronchiolitis hospitalization are associated with developing asthma.^{21,26}

Our objectives of this retrospective cohort study were (1) to determine the prevalence of asthma within 5 years of discharge after index bronchiolitis hospitalization in a patient population with high asthma baseline prevalence and (2) to determine clinical factors during the index bronchiolitis hospitalization associated with asthma diagnosis. We hypothesized that clinical variables related to the severity of bronchiolitis would be associated with higher odds of asthma diagnosis within 5 years after discharge.

METHODS

Data Source

The study cohort was composed of infants aged 0 to 12 months admitted to an urban, tertiary-care hospital from January 1, 2007, to December 31, 2009, with a primary diagnosis of bronchiolitis, based on *International Classification of Diseases, Ninth Revision* codes from billing data (466.11 and 466.19). This age range was selected in an attempt to exclude older infants who might have viral-induced wheezing and early asthma. Infants with a history of chronic lung disease, bronchopulmonary dysplasia, and/or cystic fibrosis were excluded. The setting was an urban, tertiary-care children's hospital with >8800 admissions each year and ~400 annual bronchiolitis admissions with an average length of stay of 2.0 days.²⁶

Outcome Measure

Asthma diagnosis was the outcome measure, collected during a 5-year follow-up period ending between 2012 and 2014 after the discharge date of each bronchiolitis

hospitalization. A positive asthma diagnosis was defined as 1 or more of the following: (1) a hospitalization, ED visit, or outpatient visit for asthma, (2) asthma listed on the patient's problem list, and/or (3) a prescription for asthma controller medication: inhaled corticosteroids (fluticasone, beclomethasone, budesonide), inhaled corticosteroids with long-acting albuterol (fluticasone and salmeterol, budesonide and formoterol), and/or leukotriene receptor antagonists (montelukast). Asthma diagnosis was based on *International Classification of Diseases, Ninth Revision* codes from billing data (493.00, 493.01, 493.01, 493.02, 493.10, 493.11, 492.12, 493.20, 493.21, 493.22, 493.90, 493.91, and/or 493.92).

Data Collection

Data were extracted from the medical record via individual chart review. Variables collected on each patient included demographic characteristics, data from previous medical history, data from social and family history, and clinical variables from the index bronchiolitis hospitalization. A socioeconomic status z score was assigned to each patient on the basis of their recorded addresses and the average income of that neighborhood. Zero represents the average socioeconomic status in the United States; positive numbers represent higher socioeconomic status, whereas negative numbers represent less than average socioeconomic status. For clinical variables, an infant was recorded as receiving respiratory support if any of the following were used for treatment: high-flow nasal cannula, bilevel positive airway pressure, and/or intubation. Prematurity was defined as gestational age <37 weeks.

Statistical Analysis

Data are reported as medians with interquartile ranges (IQRs) for continuous variables or as frequency with percentages for categorical variables. Associations with the outcome of asthma diagnosis were measured by using a χ^2 test or Fisher's exact test for categorical variables and Wilcoxon rank test for continuous variables because all continuous variables were not normally distributed. Variables with $P <$

.2 in bivariate analysis were further examined in a multivariable logistic regression model with asthma diagnosis as the outcome and without a presumed primary predictor variable. Then, a backward, stepwise process was used whereby the least significant variables were eliminated 1 by 1 until a parsimonious model with only variables with a significance level of $P < .05$ remained to be presented in the final model. All statistics were completed by using Stata software release 15 (Stata Corp, College Station, TX).

Although there was no presumed primary predictor in our model, we chose a well-documented factor, that of infant age at bronchiolitis hospitalization, to determine if we had adequate power. We estimated that ~400 patients would be hospitalized with bronchiolitis during our study period of 3 years on the basis of data from a recent randomized controlled trial at the same institution of patients with bronchiolitis.²⁷ Using these data and a presumed 50% rate of asthma in our population derived from a similar study,²⁸ we found that to find a difference of 1 month in age between the patients with and without a future asthma diagnosis, assuming an SD of 3 months of age, we would have >91% power.

RESULTS

A total of 534 patients with a median age of 4.4 months (IQR 1.9–6.4) were included in the cohort. A total of 294 (55.1%) met criteria for asthma diagnosis within 5 years of the bronchiolitis hospitalization discharge. Among those, 102 (19.1%) required hospitalization for asthma, 195 (36.5%) had ED visits for asthma, 183 (34.3%) had outpatient visits for asthma, 175 (32.8%) had asthma added to their problem list, and 177 (33.2%) were prescribed an asthma controller medication during the 5-year follow-up period. There was considerable overlap in asthma diagnosis, medical care sought, and asthma medication prescribed (Fig 1).

Patients who did not have follow-up data were included in the “asthma-free” group. In a separate deidentified cohort of infants hospitalized for bronchiolitis in 2007–2009 composed of 879 infants

<12 months old, 91.3% returned to our system at least once for medical care within the 5-year period, and 82.9% returned within the first year after discharge. This return for medical care was defined as any diagnosis added to the electronic medical record; a diagnosis added captures any inpatient visits, ED visits, outpatient visits, laboratory visits, and prescriptions written, each of which must be linked to a diagnosis in the electronic medical record. This represents an attrition rate of <9% for a similar cohort of patients for both the asthma and asthma-free outcome combined.

In an unadjusted, bivariate analysis (Table 1), factors during the index bronchiolitis hospitalization that were associated with future asthma diagnosis included older age ($P \leq .001$), male sex ($P \leq .001$), black race ($P \leq .001$), history of asthma in a first-degree relative ($P \leq .001$), maternal history of asthma ($P = .03$), paternal history of asthma ($P = .02$), sibling history of asthma ($P = .01$), higher number of albuterol treatments received per day of bronchiolitis hospitalization ($P \leq .001$), and negative status for RSV ($P \leq .001$). No other demographic characteristics or clinical markers of severity were associated with asthma diagnosis.

In an adjusted multivariate logistic regression analysis (Tables 2 and 3), factors independently associated with asthma diagnosis after bronchiolitis hospitalization included age in months, sex, race, and family history of asthma in a first-degree relative. We found a statistically significant interaction between age and family history of asthma and stratified the model by family history to address this effect modification. In both models, sex is a significant predictor of future asthma, with an odds ratio (OR) for female versus male sex of 0.46 for both groups, with the 95% confidence interval (CI) slightly wider for those with a family history of asthma. However, age and race were only statistically significant predictors of asthma for those infants hospitalized with bronchiolitis without a family history of asthma. For each month of age at the time of bronchiolitis admission, the odds of future asthma diagnosis increased by 19%

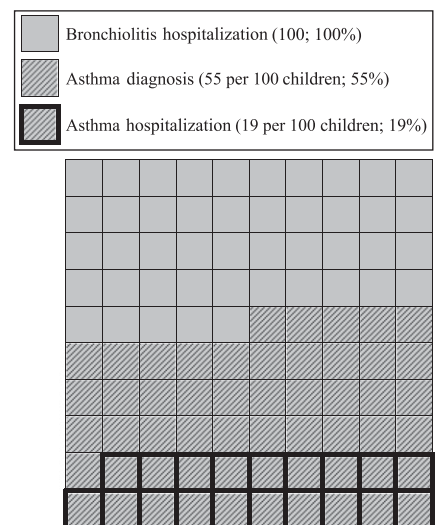


FIGURE 1 Asthma outcomes for patients within 5 years of bronchiolitis hospitalization.

(95% CI 1.08–1.32). The OR of black race when compared to white race was 4.06 (95% CI 1.56–10.58).

The following clinical variables during the index bronchiolitis hospitalization were not independently associated with future asthma diagnosis: length of hospitalization, pediatric ICU stay, albuterol treatments per day, supplemental oxygen requirement, respiratory support, highest respiratory rate, and RSV infection.

We conducted a post hoc power analysis to determine if we had adequate power to detect the differences in the independent factors associated with the asthma outcome in our model. We calculated high power to detect family history (98%), sex (96%), and age (>99%), but there was lower power to detect the difference in race (71%).

DISCUSSION

This study revealed that more than half of the infants hospitalized with bronchiolitis before age 12 months in a region of high asthma prevalence in the United States were subsequently diagnosed with asthma within 5 years of the index discharge, and almost 1 in 5 were hospitalized for asthma within 5 years of the index discharge. Once hospitalized for severe bronchiolitis, no additional clinical factors indicating severity of illness, such as intensive care stay,

TABLE 1 Patient Characteristics During Bronchiolitis Admission and Asthma Diagnosis Within 5 Years

Variable ^a	All Patients N = 534	Asthma Outcome		P ^b
		No (n = 240)	Yes (n = 294)	
Demographic characteristics				
Age, mo	3.5 (1.9 to 6.5)	2.8 (1.6 to 5.3)	4.3 (2.3 to 7.1)	<.0001
Female	41.0 (219)	50.0 (120)	33.7 (99)	<.0001
Race ^b				<.0001
White	12.7 (53)	18.1 (31)	9 (22)	
Black	32.9 (138)	26.9 (46)	37 (92)	
Other	54.4 (228)	55.0 (94)	54 (134)	
Hispanic ^c	60.2 (312)	60.7 (136)	59.9 (176)	.85
Medicaid	71.5 (382)	70.8 (170)	72.1 (212)	.75
Socioeconomic status z score ^c	-3.5 (-6.6 to -1.4)	-3.4 (-6.5 to -1.2)	-3.6 (-6.6 to -1.7)	.17
Patient history				
Prematurity ^c	22.2 (118)	19.7 (47)	24.2 (71)	.21
Family and social history				
Family asthma history ^c	45.3 (236)	35.0 (84)	51.7 (152)	<.0001
Maternal asthma history ^c	21.8 (115)	17.4 (41)	25.4 (74)	.03
Paternal asthma history ^c	15.1 (79)	11.1 (26)	18.3 (53)	.02
Sibling asthma history ^c	25.1 (132)	18.2 (43)	30.6 (89)	.001
Secondhand smoke exposure ^c	23.2 (76)	18.8 (27)	26.6 (49)	.10
Day care attendance ^c	12.5 (36)	10.7 (13)	13.8 (23)	.44
Dog at home ^c	11.2 (53)	12.8 (27)	9.9 (26)	.31
Cat at home ^c	10.3 (49)	10.4 (22)	10.2 (27)	.94
Hospitalization characteristics				
Length of stay, d	2.9 (1.9 to 4.2)	2.8 (1.9 to 4.4)	2.9 (2.0 to 4.1)	>.999
Pediatric intensive care stay	10.1 (54)	12.5 (30)	8.2 (24)	.10
Albuterol treatments per d	0.4 (0.0 to 3.1)	0 (0 to 1.3)	0.7 (0 to 4.5)	<.0001
Supplemental oxygen	48.1 (257)	50.8 (122)	45.9 (135)	.26
Any respiratory support	5.2 (28)	6.7 (16)	4.1 (12)	.18
Continuous positive airway pressure	5.1 (27)	6.7 (16)	3.7 (11)	.13
Intubation	0.8 (4)	1.3 (3)	0.3 (1)	.33
Highest respiratory rate	50 (44 to 57)	50 (44 to 56)	50 (44 to 58)	.55
RSV ^c	46.1 (207)	53.2 (108)	40.2 (99)	.001

^a Values listed as percent (number) or median (IQR).

^b χ^2 and Fisher's exact tests were used to evaluate *P* values for categorical variables. Wilcoxon rank test was used to evaluate *P* values for continuous variables.

^c For race, the *n* = 419; for Hispanic ethnicity, *n* = 518; for socioeconomic status, *n* = 518; for prematurity, *n* = 532; for family history, *n* = 528; for maternal history, *n* = 527; for paternal history, *n* = 525; for sibling history, *n* = 527; for secondhand smoke exposure, *n* = 327; for day care attendance, *n* = 288; for dog at home, *n* = 475; for cat at home, *n* = 475; for RSV, *n* = 449.

respiratory support, or supplemental oxygen, were associated with increased odds of future asthma. Our findings confirmed demographic factors previously shown to be associated with increased odds of asthma after bronchiolitis hospitalization: older age at hospitalization, black race, and family history of asthma. However, there were modified effects of each contributor by family history of asthma. Age and race were only significant

predictors in children without a family history of asthma.

More than half (55.1%) of our study cohort were diagnosed with asthma, which is greater than the reported asthma prevalence (22%–48%) in similar studies, indicating a potential increased burden of postbronchiolitis asthma in our patient population.^{3,5,6} Nearly one-fifth (19.1%) of the study cohort was later hospitalized for asthma, indicating not just the high

prevalence of asthma after bronchiolitis but also a high severity of disease.

The lack of association between clinical variables during bronchiolitis hospitalization and future asthma is consistent with and expands on findings from a smaller prospective study that was focused on RSV bronchiolitis, in which authors also did not find any clinical associations.⁵ However, our study contrasts with another that did reveal an association

TABLE 2 Multivariable Model for Patient Characteristics During Bronchiolitis Admission Associated With Asthma Diagnosis Within 5 Years of Discharge for Patients Without a Family History of Asthma

Variable	OR	95% CI
Age, mo	1.19	1.08–1.32
Female	0.46	0.26–0.81
Race		
White	Reference	—
Black	4.06	1.56–10.58
Other	3.19	1.3–7.83

—, not applicable.

between length of hospitalization and respiratory rate with future asthma.²⁶ The differences may lie in the fact that this cohort was established for a clinical trial, it was conducted in multiple international sites with varied populations, the prevalence of asthma was considerably lower, and 4 definitions of asthma each with different prevalences (6%–36%) were used, including parental report only. Another previous study revealed a “dose-dependent” relationship between the acuity of the setting in which the bronchiolitis was treated (outpatient, ED, hospital) and risk of future asthma.⁶ In our study, we did not find that dose dependence continued to be a predictor once the threshold of hospitalization was reached. There were no clinical factors of the severity of the hospitalization, including whether the

TABLE 3 Multivariable Model for Patient Characteristics During Bronchiolitis Admission Associated With Asthma Diagnosis Within 5 Years of Discharge for Patients With a Family History of Asthma

Variable	OR	95% CI
Age, mo	1.06	0.94–1.18
Female	0.46	0.24–0.9
Race		
White	Reference	—
Black	2.49	0.87–7.14
Other	1.82	0.67–4.89

—, not applicable.

patient required respiratory support or ICU stay, that were associated with the outcome of asthma 5 years after the bronchiolitis admission. Although, only 10% of the population required intensive care, and only 5% required respiratory support. This may limit the power to associated those variables with the outcome.

In the unadjusted, bivariate analysis, albuterol treatments per day while hospitalized for bronchiolitis were significantly associated with future asthma diagnosis. Current American Academy of Pediatrics guidelines advise against administering albuterol to infants with bronchiolitis because of a lack of evidence of efficacy.²⁹ However, infants in this study cohort presented with bronchiolitis during 2007 to 2009, a period in which the American Academy of Pediatrics 2006 guidelines were in use and recommended a trial of albuterol treatment as an option for bronchiolitis treatment with continuation of albuterol therapy if the trial provided clinical improvement.³⁰ Therefore, increased albuterol doses among our patients may have indicated clinical responsiveness, and thus an early sign of asthma. This unadjusted, bivariate association between albuterol doses during bronchiolitis admission and future asthma was not seen in adjusted analysis and was not an independent predictor of asthma in this population.

In the adjusted analysis, the demographic factors independently associated with asthma diagnosis (older age, male sex, Black race, and family history of asthma in a first-degree relative) were similar to findings in previous studies.^{5,13,15–21} However, we report a new finding, that age and race were only significant predictors in children without a family history of asthma. Previous studies have revealed that family history is a strong predictor of asthma,^{5,14–17} and in our cohort of those diagnosed with asthma within 5 years of discharge, 52% had a first-degree family member with asthma. We hypothesize that this risk factor of family history is so strong that when we stratified by family history of asthma, there were no other risk factors that were clinically significant. As a result, we suggest a

screening question of simply whether a sibling or parent carries a diagnosis of asthma can be the most helpful predictor to help guide families to prepare and anticipate asthma in their child's future.

Socioeconomic and Medicaid status were not independently associated with postbronchiolitis asthma. Although black race was associated with future asthma diagnosis in patients without a family history of asthma, census tract z score of socioeconomic status was not associated with the outcome. Having both variables in our model and finding only 1 to be significant in the stratified model helped to untangle the possible confounding association between race and socioeconomic status. We acknowledge that because there was lower power (71% in post hoc analysis) to detect differences in race, our findings should be interpreted with caution. In addition, the majority of the patient population had a low socioeconomic score (averaging ~3.5 SDs below the national mean), which may limit the ability to assess how differences in socioeconomic status modulate the odds of future asthma.

We also did not find that prematurity was independently associated with future asthma, which was contrary to a retrospective cohort study in which authors measured recurrent wheezing after an episode of RSV bronchiolitis.⁵¹ In our study, we used a stricter definition of asthma to capture only physician-diagnosed asthma, as compared with a broad definition of recurrent wheeze, which may account for these discordant results. In addition, we did not account for degree of prematurity, which may have better defined an association if 1 existed, which is a limitation of our study. We also excluded patients with bronchopulmonary dysplasia and other chronic lung diseases, so the premature population captured in our cohort likely comprises the infants with higher gestational age who have less prematurity-associated medical complications.

Several limitations of this study should be considered. First, the retrospective study cohort was from a single hospital, which serves a community with a high prevalence of asthma. Therefore, these results are most

generalizable to similar urban populations with high asthma prevalence, and although we recognize that this excludes generalizability to all children, we highlight that urban populations with high asthma prevalence stand to benefit significantly from asthma-related research. Second, some clinical variables, such as supplemental oxygen requirement and the number of albuterol treatments, can be highly influenced by physician discretion and may not be reflective of the same practice at other institutions. Third, our study was limited by the lack of a control group. As a result, we were unable to determine relative risk. Lastly, we were unable to account for patients lost to follow-up. However, we found an attrition rate <9% in a similar cohort, and therefore, any misclassification due to loss to follow-up would be unlikely to change our findings.

Future research should include a prospective cohort study with a control group to quantify the risk for potential determinants. Because the factors identified in this study as associated with asthma diagnosis were not modifiable, targeted counseling should be focused on general asthma awareness with education regarding the patient's odds of developing asthma and trigger reduction.

CONCLUSIONS

Infants from a population with high asthma prevalence hospitalized with bronchiolitis had a high prevalence of asthma diagnosis and health care use for asthma during the 5-year period post discharge. The severity of illness and clinical factors during hospitalization were not associated with future asthma diagnosis. First-degree family history of asthma remains highly associated with future diagnosis of asthma in infants hospitalized with bronchiolitis, but other demographic factors including age and sex are only associated in those children with no family history of asthma. These data should encourage clinicians to discuss anticipatory asthma guidance with families of infants hospitalized with bronchiolitis, particularly those physicians in urban communities with high asthma prevalence.

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REFERENCES

- Hasegawa K, Tsugawa Y, Brown DF, Mansbach JM, Camargo CA Jr. Trends in bronchiolitis hospitalizations in the United States, 2000-2009. *Pediatrics*. 2013;132(1):28-36
- Miller EK, Gebretsadik T, Carroll KN, et al. Viral etiologies of infant bronchiolitis, croup and upper respiratory illness during 4 consecutive years. *Pediatr Infect Dis J*. 2013;32(9):950-955
- Balekian DS, Linnemann RW, Hasegawa K, Thadhani R, Camargo CA Jr. Cohort study of severe bronchiolitis during infancy and risk of asthma by age 5 years. *J Allergy Clin Immunol Pract*. 2017;5(1):92-96
- Henderson J, Hilliard TN, Sherriff A, Stalker D, Al Shammari N, Thomas HM. Hospitalization for RSV bronchiolitis before 12 months of age and subsequent asthma, atopy and wheeze: a longitudinal birth cohort study. *Pediatr Allergy Immunol*. 2005;16(5):386-392
- Bacharier LB, Cohen R, Schweiger T, et al. Determinants of asthma after severe respiratory syncytial virus bronchiolitis. *J Allergy Clin Immunol*. 2012;130(1):91-100.e3
- Carroll KN, Wu P, Gebretsadik T, et al. The severity-dependent relationship of infant bronchiolitis on the risk and morbidity of early childhood asthma. *J Allergy Clin Immunol*. 2009;123(5):1055-1061, 1061.e1
- Roemer M. *Health Care Expenditures for the Five Most Common Children's Conditions, 2008: Estimates for U.S. Civilian Noninstitutionalized Children, Ages 0-17*. Rockville, MD: Agency for Healthcare Research and Quality; 2011
- Garg R, Karpati A, Kelighton J, Perrin M, Shah M. *Asthma Facts*. 2nd ed. New York City, NY: Department of Health and Mental Hygiene; 2003
- Akinbami LJ. *Advance Data from Vital and Health Statistics. No 381: The State*

of Childhood Asthma, United States, 1980-2005. Hyattsville, MD: National Center for Health Statistics; 2006

- Warman K, Silver EJ, Wood PR. Modifiable risk factors for asthma morbidity in Bronx versus other inner-city children. *J Asthma*. 2009;46(10):995-1000
- US Census Bureau. Quick facts Bronx County (Bronx Borough), New York. 2010. Available at: <https://www.census.gov/quickfacts/fact/table/bronxcountybronxboroughnewyork/PST045217>. Accessed July 22, 2019
- Centers for Disease Control and Prevention. Asthma: most recent asthma data. 2018. Available at: https://www.cdc.gov/asthma/most_recent_data.htm. Accessed October 27, 2018
- New York State Department of Health. *Asthma Hospitalization Rate Per 10,000 - Aged 5-11 Years*. Oneonta, NY: New York State Department of Health; 2016
- Mikalsen IB, Halvorsen T, Eide GE, Øymar K. Severe bronchiolitis in infancy: can asthma in adolescence be predicted? *Pediatr Pulmonol*. 2013;48(6):538-544
- Cassimos DC, Tsalkidis A, Tripsianis GA, et al. Asthma, lung function and sensitization in school children with a history of bronchiolitis. *Pediatr Int*. 2008;50(1):51-56
- Piippo-Savolainen E, Remes S, Kannisto S, Korhonen K, Korppi M. Early predictors for adult asthma and lung function abnormalities in infants hospitalized for bronchiolitis: a prospective 18- to 20-year follow-up. *Allergy Asthma Proc*. 2006;27(4):341-349
- Koponen P, Helminen M, Paasilta M, Luukkaala T, Korppi M. Preschool asthma after bronchiolitis in infancy. *Eur Respir J*. 2012;39(1):76-80
- Al-Shawwa B, Al-Huniti N, Abu-Hasan M. Respiratory syncytial virus bronchiolitis and risk of subsequent wheezing: a matter of severity. *Pediatr Asthma Allergy Immunol*. 2006;19(1):26-30
- Mikalsen IB, Halvorsen T, Øymar K. The outcome after severe bronchiolitis is

- related to gender and virus. *Pediatr Allergy Immunol.* 2012;23(4):391–398
20. Lin HW, Lin SC. Environmental factors association between asthma and acute bronchiolitis in young children—a perspective cohort study. *Eur J Pediatr.* 2012;171(11):1645–1650
 21. Bergroth E, Aakula M, Korppi M, et al. Post-bronchiolitis use of asthma medication: a prospective 1-year follow-up study. *Pediatr Infect Dis J.* 2016;35(4):363–368
 22. Bodart E, Just J, Grimfeld A, Costil J. [A retrospective survey on the respiratory course of severe bronchiolitis]. *Arch Fr Pediatr.* 1993;50(7):573–576
 23. Midulla F, Nicolai A, Ferrara M, et al. Recurrent wheezing 36 months after bronchiolitis is associated with rhinovirus infections and blood eosinophilia. *Acta Paediatr.* 2014;103(10):1094–1099
 24. Ehlenfeld DR, Cameron K, Welliver RC. Eosinophilia at the time of respiratory syncytial virus bronchiolitis predicts childhood reactive airway disease. *Pediatrics.* 2000;105(1 pt 1):79–83
 25. Mikalsen IB, Halvorsen T, Øymar K. Blood eosinophil counts during bronchiolitis are related to bronchial hyper-responsiveness and lung function in early adolescence. *Acta Paediatr.* 2014;103(1):86–92
 26. Lu S, Hartert TV, Everard ML, et al. Predictors of asthma following severe respiratory syncytial virus (RSV) bronchiolitis in early childhood. *Pediatr Pulmonol.* 2016;51(12):1382–1392
 27. Silver AH, Esteban-Cruciani N, Azzarone G, et al. 3% hypertonic saline versus normal saline in inpatient bronchiolitis: a randomized controlled trial. *Pediatrics.* 2015;136(6):1036–1043
 28. Bacharier LB, Cohen R, Schweiger T, et al. Determinants of asthma after severe respiratory syncytial virus bronchiolitis. *J Allergy Clin Immunol.* 2012;130(1):91–100.e3
 29. Ralston SL, Lieberthal AS, Meissner HC, et al; American Academy of Pediatrics. Clinical practice guideline: the diagnosis, management, and prevention of bronchiolitis. *Pediatrics.* 2014;134(5). Available at: www.pediatrics.org/cgi/content/full/134/5/e1474
 30. American Academy of Pediatrics Subcommittee on Diagnosis and Management of Bronchiolitis. Diagnosis and management of bronchiolitis. *Pediatrics.* 2006;118(4):1774–1793
 31. Escobar GJ, Masaquel AS, Li SX, Walsh EM, Kipnis P. Persistent recurring wheezing in the fifth year of life after laboratory-confirmed, medically attended respiratory syncytial virus infection in infancy. *BMC Pediatr.* 2013;13(1):97

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