Published in final edited form as:

J Asthma. 2012 February ; 49(1): 23–28. doi:10.3109/02770903.2011.637596.

Impact of Delay in Asthma Diagnosis on Chest X-ray and Antibiotic Utilization by Clinicians

Brian A. Lynch, M.D.¹, Yilma Fenta, M.D.¹, Robert M. Jacobson, M.D.¹, Xujian Li, M.S.², and Young J. Juhn, M.D., M.P.H.^{1,*}

¹Division of Community Pediatric and Adolescent Medicine, Department of Pediatric and Adolescent Medicine, Mayo Clinic, Rochester, MN, USA

²Department of Biomedical Statistics and Informatics, Mayo Clinic, Rochester, MN, USA

Abstract

Objective—To evaluate the effect of the timeliness of asthma diagnosis on chest X-ray (CXR) and antibiotic utilization in children.

Patients and methods—This was a retrospective cohort study of 276 asthmatic children aged 5–12 years from Rochester, Minnesota. From the time when children met our predetermined asthma criteria, the frequency of CXR and antibiotic utilizations for respiratory illnesses were collected from medical records until age 18 years. Using a Poisson regression model, the frequency of CXR and antibiotic utilizations were compared in children with timely, delayed, or no clinician diagnosis of asthma.

Results—Of the 276 asthmatic patients, 97 (35%) had a timely diagnosis, 122 (44%) had a delayed diagnosis, while 57 patients (21%) had no clinician diagnosis of asthma. There was no significant difference in CXR or antibiotic utilization for respiratory illness between these groups. In addition, this was true for the comparison between the timely diagnosed group and the delayed diagnosed group combining both the group with a delay in asthma diagnosis and the group who never had asthma diagnosis.

Conclusions—A delay in the diagnosis of asthma in children is common and overall it may not influence antibiotic and CXR utilization for respiratory symptoms by clinicians. However, its impact on access to asthma-related therapies and other healthcare utilizations could be possible and was not assessed in this study. Given the limitations of our study, a larger prospective study needs to be considered.

Keywords

adolescent; antibacterial agents; child; health services; radiography; therapeutics; thoracic

Introduction

Recent studies reported that compared to those without asthma, individuals with asthma in the United States are more likely to spend days sick in bed, to miss school, and to suffer

Copyright © 2012 Informa Healthcare USA, Inc.

*Corresponding author: Young J. Juhn, M.D., M.P.H., Division of Community Pediatric and Adolescent Medicine, Department of Pediatric and Adolescent Medicine, Mayo Clinic, Baldwin 3B, 200 1st Street SW, Rochester, MN 55905, USA; Tel: 507-538-6522; Fax: 507-284-9744; juhn.young@mayo.edu.

Declaration of Interest

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

activity or work limitations (1, 2). The total incremental cost of asthma to society in 2007 was estimated to be \$56 billion (1), suggesting that asthma is a significant medical and economic burden to society. In addition, a delay in diagnosing as well as a failure to diagnose asthma in children are common and can lead to inadequate asthma therapy resulting in additional morbidities and diminished quality of life (3–8). We previously reported that almost two-thirds of children who met the criteria for asthma were not diagnosed with asthma with the median delay of 3.3 years (3) and this diagnostic delay increases urgent care utilization but not emergency room utilization or systemic corticosteroid use for asthma concerns (9).

In children with asthma, antibiotics are frequently used for wheezing (10, 11). A recent 1-year study of 892,841 Belgian children found that in 35.6% of children with an asthma drug dispensed, an antibiotic was dispensed on the same day and that there was more frequent dispensing of antibiotics to children who received an asthma drug compared to those who did not (12). Another recent study of 60.4 million asthma visits from 1998 to 2007 found that antibiotics were prescribed at nearly one in six pediatric ambulatory care visits for asthma when the need for antibiotics was not otherwise justified by another ICD-9 code (13). Recent studies show that antibiotic treatment reduced exacerbations of asthma and may offer some benefit for managing pneumonia associated with asthma (14–17). However, the current guidelines do not recommend antibiotics for treatment of asthma routinely (18). Concerns regarding increasing antibiotic resistance and inappropriate prescribing led to public health efforts to decrease antibiotic use starting in the 1990s (19, 20).

Chest X-rays (CXR) are ordered commonly at asthma visits. A 2005 study of 85,618 pediatric emergency room visits found that CXRs were ordered at 28.6% of visits for asthma (21). CXRs are not routinely recommended for acute evaluation of children with asthma but may be needed to exclude other diagnoses (18). CXRs ordered for children with wheezing offer little diagnostic assistance, especially when children are afebrile without localized findings by auscultatory examination (22–24). Even in children with asthma admitted to the hospital with respiratory difficulty, the yield of CXR evaluations is low (25). In addition, CXRs make a notable contribution to the collective radiation risk of the pediatric population (26).

Currently, little is known about the impact of a delay in asthma diagnosis on treatments and health services not routinely recommended for the management of asthma such as CXR evaluations and antibiotic treatments. The main reasons for the lack of this information are difficulties in determining a delay in asthma diagnosis and capturing all CXR and antibiotic utilizations for all study subjects reliably. In addressing this question, our study setting has unique strengths. Because our study setting is a self-contained healthcare environment with a unified medical record system in the community for research, we are able to capture all events for CXR evaluations and antibiotic therapies. In addition, we previously assembled a cohort of children with asthma in whom we ascertained asthma status based on predetermined criteria and determined the timeliness of diagnosis of asthma (3). Using this same cohort, we conducted a retrospective cohort study to assess the impact of a delay in asthma diagnosis on CXR and antibiotic utilizations in children during their first 18 years of life. We hypothesized that a delay in the diagnosis of asthma leads to more diagnostic uncertainty with respiratory illness, which results in increased CXR and antibiotic utilization in children with asthma.

Patients and Methods

Study Design and Setting

This was a retrospective cohort study conducted in Rochester, Minnesota, located in Olmsted County. The study protocol was approved by the Institutional Review Boards at both the Mayo Clinic and the Olmsted Medical Center. Medical care in Rochester is virtually self-contained within these two medical centers because, geographically, there are no other local medical clinic options. All inpatient and outpatient data have been indexed in an automated form since 1935 (27). Characteristics of the city of Rochester and Olmsted County populations were similar to those of the US Caucasian population, with the exception of a higher proportion of the working population employed in the healthcare industry.

Study Subjects

Study subjects were a cohort of children who participated in a vaccine study, and the details regarding the study subjects were previously described by Molis et al. (3). Briefly, the original study cohort (a population-based stratified sample) of 876 children aged 5–13 years at the time of the original study was identified and enrolled from all children who attended the Rochester School District in 1993. At the time of our data collection for this study in 2008, all subjects were older than 18 years. Among these 876 children, 276 met the criteria for asthma.

Ascertainment of Asthma Cases

The asthma index or incidence date was the earliest constellation of symptoms that met predefined criteria for asthma regardless of whether clinicians diagnosed the patient with asthma. The details of predetermined criteria for asthma were previously described by Molis et al. (3). Clinician-diagnosed asthma was defined as documentation of one of the following terms: asthma, bronchial asthma, asthmatic bronchitis, allergic or exogenous or extrinsic asthma, intrinsic or endogenous or nonallergic asthma, or reactive airway disease. A timely asthma diagnosis was defined when asthma diagnosis was documented at the same time as when one met the criteria for asthma (index date). A delayed asthma diagnosis was defined as any delay between the index date and the clinician's diagnosis date while no clinician asthma diagnosis was defined as the presence of an index date without any clinician documentation of an asthma diagnosis. Previous asthma epidemiology research utilized similar criteria to define asthma (3, 28, 29) and found this to be reliable (30).

Dependent Variables

The dependent variables in this study were the frequency of CXR and oral antibiotic utilizations for lower respiratory illnesses during the first 18 years of life. We calculated the frequency of CXR and antibiotic utilizations from the index date of asthma (i.e., one met the criteria for asthma) to the age of last follow-up or age 18 years, whichever came first. Antibiotic utilization was defined as an oral treatment course for an acute medical condition. Antibiotic treatments were not included if they were started within 14 days for the same medical condition or if they were used as prophylaxis. Any CXR (posteroanterior, lateral, or both) was included in the analysis. Respiratory illness was defined as clinician diagnoses of bronchiolitis, bronchitis, bronchospasm, bronchospastic cough, cough, pneumonia/pneumonitis, shortness of breath, or wheezing documented in medical records.

Independent Variable

The primary independent variable for this study was the timeliness of asthma diagnosis. Children with predetermined asthma criteria were categorized into three groups: (1) those

who had never been diagnosed with asthma as of their 18th birthday, (2) those who had a delayed diagnosis of asthma, and (3) those who had a timely diagnosis of asthma. A secondary analysis of this study was to identify other risk factors affecting overall CXR and antibiotic utilization from the index date to the age of last follow-up or age 18 years.

Statistical Analysis

Using a Poisson regression model (SAS procedure GENMOD), the incidence density rates offset by the follow-up duration (events per person-year), the risk ratios (RRs), and corresponding 95% confidence intervals (CIs) were calculated for CXR and oral antibiotic utilizations in children with a timely, delayed, or no clinician diagnosis of asthma. Poisson regression models were fit to determine the RR and corresponding 95% CI between other factors (age, gender, ethnicity, clinician-graded asthma severity at index date of asthma, tobacco smoke exposure, and years of maternal education) and overall CXR or antibiotic utilization. The observations used in the Poisson regression models were the actual number of CXR evaluations and antibiotic treatments from the asthma index date to the date of last follow-up or age 18 years, whichever came first. All calculated *p*-values were two-sided and *p*-values <.05 were considered statistically significant. Statistical analyses were performed using the SAS software package (SAS version 9.2; SAS Institute, Inc., Cary, NC, USA).

Results

Study Subjects

Of the 276 children who met the criteria for asthma (median age at the index date, 7.9 years), 150 (54%) were males, 259 (94%) were Caucasians, 97 (35%) had a timely asthma diagnosis, 122 (44%) had delay in asthma diagnosis, while 57 (21%) had no clinician-diagnosis of asthma prior to age 18 years or date of last follow-up. The details of the sociodemographic and clinical characteristics of the study subjects are described in Table 1. There was no significant difference in follow-up duration among the comparison groups (*p* = .25).

Influence of a Delay in Asthma Diagnosis on CXR Utilization and Antibiotic Treatments

The influence of a delay in asthma diagnosis on the frequency of CXR and antibiotic utilizations for respiratory illnesses is summarized in Table 2. The timeliness of asthma diagnosis did not significantly affect CXR or antibiotic utilization. There was a nonsignificant trend showing increased CXR (RR: 1.47, CI: 0.97–2.23; *p* = .067) and antibiotic (RR: 1.32, CI: 0.91–1.91; *p* = .15) utilization in children with a delayed compared to a timely asthma diagnosis. There were no significant differences between children with a timely diagnosis of asthma and those who had never been diagnosed with asthma in both antibiotic (RR: 0.79, CI: 0.44–1.43; *p* = .44) and CXR utilizations (RR: 0.61, CI: 0.35–1.09; *p* = .096). If we compare the frequency of antibiotic utilizations between asthmatic children with timely diagnosis and those who had a delayed diagnosis of asthma after combining both children with delayed asthma diagnosis and those who had never been diagnosed, there was no significant difference between these two groups (63 per 828 person-years vs. 67 per 898 person-years, RR: 1.02, CI: 0.70–1.49; *p* = .93) (data not shown). This was also true for CXR utilization (51 per 828 person-years vs. 56 per 898 person-years, RR: 0.99, CI: 0.64–1.51; *p* = .95).

Other Factors Associated with CXR Utilization

The results are summarized in Table 3. Children with clinician-determined mild intermittent or inactive asthma were less likely (RR: 0.67, CI: 0.47–0.96; *p* = .029) to obtain CXR than patients with persistent asthma. Children with maternal education at the high school

graduate level were less likely to utilize CXR evaluation compared to children whose mothers were college graduates (RR: 0.28, CI: 0.09–0.90; $p = .032$). Tobacco smoke exposure, ethnicity, gender, or age did not significantly affect CXR utilization.

Other Factors Associated with Antibiotic Treatments

Age, gender, ethnicity, asthma severity, tobacco smoke exposure, and maternal education did not significantly affect antibiotic utilization in our cohort of asthmatic children as summarized in Table 4.

Discussion

Our study results suggest that a delay in asthma diagnosis in children is common. A delay in asthma diagnosis does not significantly influence antibiotic and CXR utilization for respiratory symptoms.

Nearly 65% of children who met our criteria for asthma were not immediately diagnosed with asthma and this finding is concerning. We reported factors associated with this delay in asthma diagnosis and discussed the implications in our previous work (3). In this study, we rather focused on the impact of such delay in asthma diagnosis on healthcare service utilizations. Although some results approached to statistical significance, overall, there were no significant differences in antibiotic and CXR utilization between children with a timely diagnosis of asthma and those with delayed diagnosis. We postulate that although a child with a history of intermittent wheezing episodes was not diagnosed with asthma, clinicians might consider that the presence of recurrent wheezing with other symptoms in medical records might be a sufficient reason for not seeking an alternative cause or not treating with antibiotics when the child presented with lower respiratory symptoms. In addition, under the current medical reimbursement system, diagnosis using asthma symptoms such as wheezing or bronchospastic cough suffices for billing for clinical visits instead of making an actual asthma diagnosis.

Although a delayed diagnosis of asthma does not influence utilizations of antibiotics and CXRs, increased asthma severity was associated with increased CXR utilization. Children with persistent asthma were more likely to have CXRs but not antibiotic treatments compared to those with inactive or intermittent asthma. Given the literature support for an increased risk of invasive or serious pneumococcal diseases in asthmatics, especially those with more severe asthma (31, 32), it is plausible that more severe asthmatic disease may increase susceptibility to pneumonia and lead to more albeit appropriate diagnostic CXR evaluations. Although this practice might be due to the increased risk of microbial infections in asthmatics, our results did not indicate that children with more severe asthma required more frequent antibiotic therapy for respiratory illness. The potential adverse impact from exposure to radiation on young children should also be considered (26).

We previously reported that in our cohort of asthmatic children, a definite compared to probable asthma diagnosis by chart review was associated with a timely asthma diagnosis and consequently our children with a timely asthma may have more severe underlying asthma disease, which may have confounded our results for both antibiotic and CXR utilization. In understanding the impact of a delay in asthma diagnosis on healthcare service utilizations, confounding factors such as the severity and control of asthma (subjects), parental propensity to seek medical care (parents), continuity of care, or access to healthcare system (healthcare environment) should be considered. A prospective study design would be more suitable to address these factors.

Although the timeliness of asthma diagnosis does not significantly influence respiratory illness-specific antibiotic and CXR utilization overall in the first 18 years of life, timely diagnosis of asthma should be advocated for optimal asthma management and treatment. For example, during the 2009 H1N1 novel influenza season, patients who met the criteria for asthma but who did not have a physician diagnosis of asthma were not eligible for the H1N1 vaccine during the priority season for the vaccine (33). A diagnosis of asthma is also needed to provide an asthma action plan and asthma education to families (18).

Although exposure to tobacco smoke and lower socioeconomic status are known to be associated with an increased risk of upper respiratory illness (34–36), only increased maternal educational level as an indicator of socioeconomic status was found to be associated with increased CXR utilization and none of these factors were associated with increased antibiotic utilization overall in the first 18 years of life. Maternal education level may affect parental propensity to seek medical care, clinician decision-making, the continuity of care, or the access to the health system, all of which could be factors influencing CXR utilization. We believe that this might reflect a unique aspect of our study setting, a higher proportion of the working population employed in the healthcare industry. A higher proportion of college graduates work in healthcare industry and are likely to have an increased access to healthcare services compared to those with a lower maternal education level.

The results of our study need to be interpreted in the context that the prevalence of asthma in our cohort was 32% compared to most previous epidemiological reports of around 10% (37). However, the prevalence of clinician-diagnosed asthma in the original study cohort ($n = 876$) at the time of study enrollment was 15.6% (3), which is close to the prevalence of asthma in school age children in Olmsted County, Minnesota, which was 17.6% in 2002 (38). A recent cross-sectional survey identified asthma-like symptoms in 32% of preschool children, and (11) the prevalence rate of asthma may be underestimated using parental report or clinician diagnosis compared to using predetermined symptom criteria. In our study, we did not distinguish asthmatics in remission from those with active asthma symptoms and this aspect needs to be further studied in the future.

The strengths of our study include a virtually self-contained healthcare environment, unified medical record system for research, and a community-based instead of clinic-based sampling frame. In addition, the ascertainment of asthma was based on reproducible, predetermined chart criteria and not parental report or clinician diagnosis.

There are inherent limitations of our retrospective study design including unavailability of all pertinent variables such as comorbid conditions. Our study was based on a predominantly Caucasian population and our study findings may not generalize to other races. Our study was limited due to a small sample size. Our study did not assess asthma control status in comparison groups, including children whose asthma went into remission, as an outcome measure. Clinician-documented asthma severity was not controlled for in our analysis and was a likely confounding factor. While a limitation of our study was the inclusion of the time period after asthma diagnosis in the analysis, when we compared those never diagnosed with those in the other two groups, we still saw no statistical increase in CXR or antibiotic use.

In conclusion, a delay in asthma diagnosis is common in children and does not significantly affect CXR or antibiotic utilization for respiratory symptoms. A prospective study with a larger sample size would be needed to assess the effect of a timely diagnostic labeling of asthma on both asthma and nonasthma-related healthcare service utilization.

Conclusions/Key Findings

A delay in the diagnosis of asthma in children is common and overall, a delayed diagnosis of asthma may not influence clinician's antibiotic and CXR utilizations. However, its impact on access to asthma-related therapies and other healthcare utilizations could be possible and was not assessed in this study. Given the limitations of our study, a larger prospective study needs to be considered.

Acknowledgments

The study investigators have nothing to disclose. This work was supported by institutional funding from Mayo Clinic and made possible by the Rochester Epidemiology Project (R01-AR30582) from the National Institute of Arthritis and Musculoskeletal and Skin Diseases.

References

1. Barnett SB, Nurmagambetov TA. Costs of asthma in the United States: 2002–2007. *J Allergy Clin Immunol*. 2011; 127(1):145–152. [PubMed: 21211649]
2. Sullivan PW, Ghushchyan VH, Slejko JF, Belozeroff V, Globe DR, Lin SL. The burden of adult asthma in the United States: evidence from the Medical Expenditure Panel Survey. *J Allergy Clin Immunol*. 2011; 127(2):363.e1–3–369.e1–3. [PubMed: 21281868]
3. Molis WE, Bagniewski S, Weaver AL, Jacobson RM, Juhn YJ. Timeliness of diagnosis of asthma in children and its predictors. *Allergy*. 2008; 63(11):1529–1535. [PubMed: 18925889]
4. Accordini S, Cappa V, Braggion M, Corsico AG, Bugiani M, Pirina P, Verlato G, Villani S, de Marco R. The impact of diagnosed and undiagnosed current asthma in the general adult population. *Int Arch Allergy Immunol*. 2011; 155(4):403–411. [PubMed: 21346371]
5. Speight AN, Lee DA, Hey EN. Underdiagnosis and undertreatment of asthma in childhood. *Br Med J*. 1983; 286(6373):1253–1256. [PubMed: 6404413]
6. Jones A, Sykes A. The effect of symptom presentation on delay in asthma diagnosis in children in a general practice. *Respir Med*. 1990; 84(2):139–142. [PubMed: 2371436]
7. Yeatts K, Davis KJ, Sotir M, Herget C, Shy C. Who gets diagnosed with asthma? Frequent wheeze among adolescents with and without a diagnosis of asthma. *Pediatrics*. 2003; 111(5 Pt 1):1046–1054. [PubMed: 12728087]
8. Wright AL, Stern DA, Kauffmann F, Martinez FD. Factors influencing gender differences in the diagnosis and treatment of asthma in childhood: the Tucson Children's Respiratory Study. *Pediatr Pulmonol*. 2006; 41(4):318–325. [PubMed: 16477658]
9. Lynch BA, Van Norman CA, Jacobson RM, Weaver AL, Juhn YJ. Impact of delay in asthma diagnosis on health care service use. *Allergy Asthma Proc*. 2010; 21(4):e48–e52. [PubMed: 20819315]
10. Kozyrskyj AL, Dahl ME, Ungar WJ, Becker AB, Law BJ. Antibiotic treatment of wheezing in children with asthma: what is the practice? *Pediatrics*. 2006; 117(6):e1104–e1110. [PubMed: 16740813]
11. Bisgaard H, Szeffler S. Prevalence of asthma-like symptoms in young children. *Pediatr Pulmonol*. 2007; 42(8):723–728. [PubMed: 17598172]
12. De Boeck K, Vermeulen F, Meyts I, Hutsebaut L, Franckaert D, Proesmans M. Coprescription of antibiotics and asthma drugs in children. *Pediatrics*. 2011; 127(6):1022–1026. [PubMed: 21606144]
13. Paul I, Maselli J, Hersh A, Boushey HA, Nielson DW, Cabana MD. Antibiotic prescribing during pediatric ambulatory care visits for asthma. *Pediatrics*. 2011; 127(6):1014–1021. [PubMed: 21606155]
14. Johnston S, Blasi F, Black P, Martin R, Farrell D, Nieman R. The effect of telithromycin in acute exacerbations of asthma. *N Engl J Med*. 2006; 354(15):1589–1600. [PubMed: 16611950]
15. Kraft M, Cassell G, Pak J, Martin R. *Mycoplasma pneumoniae* and *Chlamydia pneumoniae* in asthma: effect of clarithromycin. *Chest*. 2002; 121:1782–1788. [PubMed: 12065339]

16. Huang YJ, Nelson CE, Brodie EL, Desantis TZ, Baek MS, Liu J, Woyke T, Allgaier M, Bristow J, Wiener-Kronish JP, Sutherland ER, King TS, Icitovic N, Martin RJ, Calhoun WJ, Castro M, Denlinger LC, Dimango E, Kraft M, Peters SP, Wasserman SI, Wechsler ME, Boushey HA, Lynch SV. National Heart, Lung, and Blood Institute's Asthma Clinical Research Network. Airway microbiota and bronchial hyperresponsiveness in patients with suboptimally controlled asthma. *J Allergy Clin Immunol.* 2011; 127(2):372 e3–381 e3. [PubMed: 21194740]
17. National Asthma Education and Prevention Program. Use of antibiotics to treat asthma exacerbations. *J Allergy Clin Immunol.* 2002; 110(5 suppl.):S180–S183. [PubMed: 12518559]
18. National Asthma Education and Prevention Program. Bethesda, MD: US Department of Health and Human Services, National Institutes of Health, National Heart, Lung and Blood Institute; 2007. Expert Panel Report 3: Guidelines for the diagnosis and Management of Asthma.
19. Kozyrskyj AL, Carrie AG, Mazowita GB, Lix LM, Klassen TP, Law BJ. Decrease in antibiotic use among children in the 1990s: not all antibiotics, not all children. *CMAJ.* 2004; 171(2):133–138. [PubMed: 15262881]
20. Perz JF, Craig AS, Coffey CS, Jorgensen DM, Mitchel E, Hall S, Schaffner W, Griffen MR. Decrease in antibiotic use among children in the 1990s: not all antibiotics, not all children. *J Am Med Assoc.* 2002; 287:3103–3109.
21. Knapp JF, Hall M, Sharma V. Benchmarks for the emergency department care of children with asthma, bronchiolitis, and croup. *Pediatr Emerg Care.* 2010; 26:364–369.
22. Roback MG, Dreitlein DA. Chest radiograph in the evaluation of first time wheezing episodes: review of current clinical practice and efficacy. *Pediatr Emerg Care.* 1998; 14(3):181–184. [PubMed: 9655657]
23. Mathews B, Shah S, Cleveland RH, Lee EY, Bachur RG, Neuman MI. Clinical predictors of pneumonia among children with wheezing. *Pediatrics.* 2009; 124(1):e29–e36. [PubMed: 19564266]
24. Zieverink SE, Harper AP, Holden RW, Klatte EC, Brittain H. Emergency room radiography of asthma: an efficacy study. *Radiology.* 1982; 145(1):27–29. [PubMed: 7122890]
25. Brooks LJ, Cloutier MM, Afshani E. Significance of roentgenographic abnormalities in children hospitalized for asthma. *Chest.* 1982; 82(3):315–318. [PubMed: 7105858]
26. Seidenbusch MC, Schneider K. Radiation exposure of children in pediatric radiology. Part 4: entrance doses achieved during the X-ray examination of the chest. *Rofo.* 2008; 180(12):1082–1103. [PubMed: 19009497]
27. Kurland LT, Molgaard CA. The patient record in epidemiology. *Sci Am.* 1981; 245(4):54–63. [PubMed: 7027437]
28. Yawn BP, Yunginger JW, Wollan PC, Reed CE, Silverstein MD, Harris AG. Allergic rhinitis in Rochester, Minnesota residents with asthma: frequency and impact on health care charges. *J Allergy Clin Immunol.* 1999; 103(1 Pt 1):54–59. [PubMed: 9893185]
29. Yunginger JW, Reed CE, O'Connell EJ, Melton LJ 3rd, O'Fallon WM, Silverstein MD. A community-based study of the epidemiology of asthma. incidence rates, 1964–1983. *Am Rev Respir Dis.* 1992; 146(4):888–894. [PubMed: 1416415]
30. Beard CM, Yunginger JW, Reed CE, O'Connell EJ, Silverstein MD. Interobserver variability in medical record review: an epidemiological study of asthma. *J Clin Epidemiol.* 1992; 45(9):1013–1020. [PubMed: 1432015]
31. Juhn YJ, Kita H, Yawn BP, Boyce TG, Yoo KH, McGree ME, Weaver AL, Wollan P, Jacobson RM. Increased risk of serious pneumococcal disease in patients with asthma. *J Allergy Clin Immunol.* 2008; 122(4):719–723. [PubMed: 18790525]
32. Talbot TR, Hartert TV, Mitchel E, Halasa NB, Arbogast PG, Poehling KA, Schaffner W, Craig AS, Griffin MR. Asthma as a risk factor for invasive pneumococcal disease. *N Eng J Med.* 2005; 352(20):2082–2090.
33. Litchfield SM. Summary recommendations by the Advisory Committee on Immunization Practices (ACIP) for the use of H1N1 influenza vaccine for the 2009–2010 vaccination season. *AAOHN J.* 2009; 57:354. [PubMed: 19842610]

34. Kum-Nji P, Meloy L, Herrod HG. Environmental tobacco smoke exposure: prevalence and mechanisms of causation of infections in children. *Pediatrics*. 2006; 117(5):1745–1754. [PubMed: 16651333]
35. Glezen WP, Greenberg SB, Atmar RL, Piedra PA, Couch RB. Impact of respiratory virus infections on persons with chronic underlying conditions. *J Am Med Assoc*. 2000; 283(4):499–505.
36. Cohen S. Social status and susceptibility to respiratory infections. *Ann N Y Acad Sci*. 1999; 896:246–253. [PubMed: 10681901]
37. Yeatts K, Shy C, Wiley J, Music S. Statewide adolescent asthma surveillance. *J Asthma*. 2000; 37(5):425–434. [PubMed: 10983620]
38. Yawn BP, Wollan P, Kurland M, Scanlon P. A longitudinal study of the prevalence of asthma in a community population of school-age children. *J Pediatrics*. 2002; 140(5):576–581.

Table 1

Comparison of demographic characteristics among the comparison groups who met the criteria for asthma.

	Timely diagnosed group (n = 97)	Delayed diagnosed group (n = 122)	Never diagnosed group (n = 57)	P-value
Gender, male (%)	45 (46.4)	74 (60.7)	31 (54.4)	.11
Age, median (IQR)	7.7 (3.5–12.7)	7.9 (4.0–11.0)	8.6 (4.1–11.7)	.73
Race, Caucasian (%)	92 (94.8)	113 (92.6)	54 (94.7)	.76
Follow-up duration in years, median (IQR)	7.9 (3.4–13.3)	9.5 (6.6–13.3)	9.0 (4.9–12.4)	.25

Note: IQR, interquartile range.

Table 2

Effect of timeliness of asthma diagnosis on frequency of CXR and antibiotic utilization for respiratory illness.

	Frequency per person-years	Relative risk (95% CI)	P-value
Chest X-ray			
No clinician asthma diagnosis	0.049	0.79 (0.44–1.43)	.44
Delayed asthma diagnosis	0.091	1.47 (0.97–2.23)	.067
Timely asthma diagnosis	0.062	Reference	
Antibiotic			
No clinician asthma diagnosis	0.047	0.61 (0.35–1.09)	.096
Delayed asthma diagnosis	0.100	1.32 (0.91–1.91)	.15
Timely asthma diagnosis	0.076	Reference	

Note: Respiratory illness was defined as clinician diagnoses of bronchiolitis, bronchitis, bronchospasm, bronchospastic cough, cough, pneumonia/pneumonitis, shortness of breath, or wheezing documented in medical records.

Table 3

Factors associated with overall CXR utilization.

<i>N</i> = 276	Frequency of CXR per person-year	Relative risk (95% CI)	P-value
Age at enrollment date			
Mean 8.74 (IQR 7–10)	0.100	1.06 (0.98–1.14)	.17
Gender			
Male (<i>n</i> = 150)	0.103	1.08 (0.76–1.53)	.66
Female (<i>n</i> = 126)	0.096	Reference	
Ethnicity			
Caucasian (<i>n</i> = 259)	0.102	1.49 (0.60–3.66)	.39
Non-Caucasian (<i>n</i> = 17)	0.069	Reference	
Asthma severity ^a			
Intermittent/inactive (<i>n</i> = 151)	0.081	0.67 (0.47–0.96)	.029
Persistent (<i>n</i> = 94)	0.121	Reference	
Tobacco smoke exposure ^b			
No (<i>n</i> = 94)	0.103	0.99 (0.64–1.53)	.96
Yes (<i>n</i> = 67)	0.104	Reference	
Maternal education ^c			
<High school (<i>n</i> = 2)	0.043	0.37 (0.02–5.75)	.48
High school graduate (<i>n</i> = 21)	0.033	0.28 (0.09–0.90)	.032
Some college (<i>n</i> = 81)	0.126	1.08 (0.71–1.66)	.72
College graduate (<i>n</i> = 67)	0.116	Reference	

Note: Bold represents statistically significant values.

^{a–c}There were missing data points for some subjects.

Table 4

Factors associated with overall antibiotic utilization.

<i>N</i> = 276	Frequency of antibiotic treatments per person-year	Relative risk (95% CI)	P-value
Age at enrollment date			
Mean 8.74 (IQR 7–10)		1.03 (0.98–1.08)	.31
Gender			
Male (<i>n</i> = 150)	0.616	0.87 (0.70–1.08)	.21
Female (<i>n</i> = 126)	0.707	Reference	
Ethnicity			
Caucasian (<i>n</i> = 259)	0.665	1.61 (0.89–2.91)	.11
Non-Caucasian (<i>n</i> = 17)	0.412	Reference	
Asthma severity ^a			
Intermittent/inactive (<i>n</i> = 151)	0.692	1.04 (0.83–1.30)	.76
Persistent (<i>n</i> = 94)	0.612	Reference	
Tobacco smoke exposure ^b			
No (<i>n</i> = 94)	0.637	0.96 (0.72–1.29)	.81
Yes (<i>n</i> = 67)	0.641	Reference	
Maternal education ^c			
<High school (<i>n</i> = 2)	0.043	0.06 (0.001–3.84)	.19
High school graduate (<i>n</i> = 21)	0.723	1.06 (0.70–1.60)	.78
Some college (<i>n</i> = 81)	0.639	0.94 (0.71–1.24)	.66
College graduate (<i>n</i> = 67)	0.680	Reference	

Note:

^{a–c}There were missing data points for some subjects.