Published in final edited form as:

Mayo Clin Proc. 2008 July ; 83(7): 786–793.

Subspecialty differences in asthma characteristics and management

Hubert Chen, MD, MPH

University of California San Francisco, San Francisco, CA

Charles A. Johnson, MD

APT Pharmaceutical, Inc., Burlingame, CA

Tmirah Haselkorn, PhD

EpiMetrix, Inc., Sunnyvale, CA

June H. Lee, MD

Genentech, Inc., South San Francisco, CA

Elliot Israel, MD

Brigham & Women's Hospital, Boston, MA

Abstract

Objective—To determine the nature and extent to which asthma characteristics and management differ between allergy and pulmonary subspecialists.

Methods—We used baseline data from 3,342 adults enrolled in The Epidemiology and Natural History of Asthma: Outcomes and Treatment Regimens (TENOR) study, a multicenter, observational cohort recruited from subspecialty practices across the United States. Information on physician subspecialty, asthma history, allergic status, lung function, medication use, and recent healthcare utilization were collected via study coordinator-administered interviews and self-administered validated questionnaires.

Results—In the TENOR study, 2,407 (72%) patients were treated by allergists and 935 (28%) by pulmonologists. Patients treated by pulmonologists were more likely to be black, less educated, and have lower incomes than those treated by allergists. Pulmonary patients had more severe asthma as indicated by physician-assessment, GINA classification, lung function, and number of asthma control problems. Regular use of a short-acting beta-agonist and systemic corticosteroid use was also higher among pulmonary patients than allergy patients, consistent with greater asthma severity. Although evidence of allergic disease was prevalent in both types of patients, allergist treated patients were more likely to receive skin testing or immunotherapy. In multivariate analyses adjusted for demographic differences, patients treated by pulmonologists were more likely to report healthcare utilization for asthma in the past 3 months.

Conclusion—In general, asthma patients treated by pulmonologists are of lower socioeconomic status, have more severe disease, require more medication, and report greater healthcare utilization than those treated by allergists.

Corresponding author: Hubert Chen, MD, MPH 350 Parnassus Avenue, Suite 609 San Francisco, CA 94143-0924 Phone: 415-502-6765; Fax: 415-476-6426 hubert.chen@ucsf.edu.

Disclosures: HC is funded in part by NIH grant K23 HL086585 and by an unrestricted fellowship grant to the University of California San Francisco from Genentech, Inc. JHL is currently employed by Genentech. TH and EI have received consultancy fees from Genentech. CAJ is a former employee of Genentech. The TENOR study was co-sponsored by Genentech and Novartis Pharmaceutical Corp.

Keywords

Asthma; Allergist; Pulmonologist; Specialty; Practice patterns; TENOR

INTRODUCTION

The management of patients with asthma can be complex, particularly for those with severe or difficult-to-treat disease. Frequently such patients are cared for by an asthma subspecialist. Several studies have demonstrated that specialist care is associated with improved asthma outcomes. The majority of these studies focus on comparing allergists to generalists.^{1–7} More recent studies have also included patients treated by pulmonologists.^{8–12} The comparison of outcomes between the different subspecialties is difficult, in large part because the type of asthma patient cared for by each subspecialty is likely to be different.

Although both allergists and pulmonologists are responsible for the care of patients with difficult-to-treat asthma, significant differences in physician training exist between the two subspecialties. Allergy training is primarily outpatient-based and focuses on the immunologic basis of disease, whereas pulmonary training gives more emphasis to the hospitalized patient and is often coupled with critical care. Some studies suggest that asthma management may vary between allergists and pulmonologists.^{8,10,12} In order to accurately interpret such information, it is essential to gain a better understanding of the differences in the patient populations treated by these two subspecialties.

The Epidemiology and Natural History of Asthma: Outcomes and Treatment Regimens (TENOR) study comprises a large, national cohort of asthma patients recruited from a diversity of allergy and pulmonary practices across the United States.¹³ The overarching objective of the TENOR study was to describe the natural history of asthma in patients assessed by physicians as severe or difficult-to-treat. The objective of the current analysis is to determine the nature and extent to which asthma characteristics and management differ between the two major subspecialties, providing additional insight to baseline data from the TENOR study.¹³

METHODS

Study Population

For this analysis, we used baseline data from 3,342 adults (≥ 8 years) in the TENOR study collected January 1, 2001 through April 30, 2004. TENOR methodology and baseline population characteristics have been previously described in detail.¹³ Briefly, TENOR was a multicenter, observational cohort study of patients with *either* severe *or* difficult-to-treat asthma recruited from specialty practice sites representing a diversity of geographic areas across the United States. Patients with mild or moderate asthma were eligible for enrollment if their pulmonologist/allergist considered their asthma difficult-to-treat. Patients with heavy smoking (≥ 30 pack-years) or a diagnosis of cystic fibrosis were excluded. There was no experimental intervention and patients continued to receive regular treatment as prescribed by their physician. Approval for the study was obtained by a central institutional review board and by the institutional review board at each site when necessary.

Data Collection in TENOR

Demographic information, medical history, and healthcare utilization were collected directly from patients at baseline via structured study coordinator-administered interviews.

Information on individual income was not collected in TENOR. To estimate median household income for subjects and site regions, we used 2000 U.S. Census data linked at the ZIP Code Tabulation Area level. Co-morbid conditions were assessed using a standardized list of common disorders. In certain circumstances, multiple items were used to assess a single health condition. For example, patients were categorized as having allergic rhinitis if they responded positively to both of the following two items: “Have you ever had a problem with sneezing or a runny or blocked nose when you did not have a cold or flu?” AND “Has a doctor ever told you that you have allergic rhinitis (hayfever, ragweed allergies)?”.

In addition to study coordinator-interviews, patients also completed several self-administered questionnaires assessing asthma symptoms, asthma triggers, and asthma-related health impairment. Number of asthma control problems was assessed using the Asthma Therapy Assessment Questionnaire (ATAQ).^{14,15} Asthma severity was determined by physician-assessment and by applying the Global Initiative for Asthma (GINA) classification scheme.^{16,17} In the case of asthma triggers, patients were asked to indicate whether they had ever had “a cough, wheeze, or other symptom of asthma as a result of exposure to any of the following circumstances” from a battery of common asthma triggers.

Lung function was evaluated annually by each site. All spirometry was performed in accordance with the American Thoracic Society guidelines.¹⁸ Results of skin test and immunotherapy were self-reported and not added to the study until 2002; thus, these data were obtained from subsequent visits in a subset of patients.¹⁹ Total serum IgE levels at baseline were measured using commercially available assays. All assays used were approved by the U.S. Food and Drug Administration for accuracy and precision, and calibrated to the World Health Organization's 2nd International Reference.²⁰

Data Analysis

Analyses were restricted to adults subjects (≥ 18 years) enrolled by either a pulmonologist or allergist. Twelve practice sites were excluded because the treating physician did not identify a subspecialty or identified a subspecialty other than pulmonology or allergy. Bivariate comparisons by subspecialty were performed using *t* tests for continuous variables and chi-square tests for categorical variables. Relationships between physician subspecialty and patient race were further explored using logistic regression models adjusting for racial composition at the site level. Racial composition (percent black) at each study site was estimated using 2000 U.S. Census data linked at the ZIP Code Tabulation Area level. For medication use, we stratified results by physician-assessed asthma severity. Due to the small proportion of patients with mild and difficult-to-treat asthma ($<4\%$), mild and moderate categories were combined. Healthcare utilization outcomes were treated as dichotomous and multiple logistic regression was used to test the association between physician specialty and outcomes while adjusting for age, gender, race/ethnicity, education, neighborhood income, and insurance status as covariates in the model. Separate regression models, unadjusted and adjusted, were evaluated for each of the six outcomes (e.g., emergency room visits, hospitalization, intubation).

RESULTS

Demographic Characteristics

In the TENOR study, 155 sites self-identified as allergy practices, 81 sites self-identified as pulmonary practices. Among those patients studied, 2,407 (72%) were treated by allergists and 935 (28%) by pulmonologists. Baseline patient characteristics are shown in Table 1. Patients treated by pulmonologists were slightly older (50 vs. 49 yrs, $p=0.01$) and had a higher BMI (31 vs. 30 kg/m², $p<0.001$) compared to those treated by allergists; however,

the differences were minor. There was also a slight gender imbalance with more women in the pulmonary group (73 vs. 70%, $p=0.05$).

Significant differences in race/ethnicity and socioeconomic status were observed between subspecialties. Pulmonologists treated a significantly greater proportion of black patients than allergists (16 vs. 10%, $p<0.001$). Patients in pulmonary practices also reported lower levels of education, were from lower income neighborhoods, and were less likely to have private health insurance. Study site characteristics are shown in Table 2. Pulmonary sites were more likely to be located in areas with a greater proportion of racial/ethnic minorities and lower median income than allergy sites. In multivariate analyses adjusting for differences in racial composition by site location, pulmonologists were still more likely to treat black patients (unadjusted OR 1.78, 95% CI [1.43, 2.22]; adjusted OR 1.52, 95% CI [1.20, 1.93]).

Although heavy smokers were excluded from TENOR, 136 (15%) pulmonary patients and 149 (6%) allergy patients reported a physician's diagnosis of emphysema or COPD ($p<0.001$). When these patients were excluded from our analyses, observed differences in age and gender by subspecialty were no longer statistically significant.

Asthma Severity and Control

Asthma severity differed significantly between the two groups (Table 3). In general, pulmonary patients were more severe than allergy patients whether classified by physicians (57 vs. 49%, $p<0.001$) or using GINA criteria^{17,21} (67 vs. 54%, $p<0.001$). Consistent with these findings, patients treated by pulmonologist were more likely to have a pre-bronchodilator FEV₁ of $\leq 60\%$ predicted and evidence of persistent airflow obstruction (defined as post-bronchodilator FEV₁/FVC ratio of $\leq 70\%$ on at least two visits 12 months apart²²). In addition, patients treated by pulmonologists reported more asthma control problems on the ATAQ as compared to those treated by allergists ($p<0.001$). In multivariate models adjusted for demographic differences, physician subspecialty remained significantly associated with asthma severity, FEV₁, and number of control problems.

Concomitant Allergic Disease

Evidence of allergic disease was prevalent in patients treated by either an allergist or pulmonologist (Table 3). Serum IgE level was elevated in both groups, but was slightly higher in the allergy treated patients (88 vs. 74 IU/ml, $p=0.009$). A non-statistical trend toward more allergic triggers (e.g. pollen, pets, molds) was also observed in the allergy group. Little to no difference was observed for other types of triggers (e.g. dust, irritants, smoke). Allergic rhinitis was more prevalent in allergy treated patients, but present in the majority of pulmonary patients as well (78 vs. 56%, $p<0.001$). The prevalence of atopic dermatitis was similar between both types of patients (13 vs. 14%, $p=0.59$).

Although evidence of allergic disease was high in both subspecialties, history of skin testing and immunotherapy was more prevalent among patients treated by allergists (Figure 1) Skin testing had been performed in 1,935 (95%) patients treated by allergists versus in only 508 (66%) of those treated by pulmonologists ($p<0.001$). Among those tested, a high proportion were positive in either group, although skin test positivity was slightly higher in patients treated by allergists (95 vs. 85%, $p<0.001$). Reported use of immunotherapy among skin test positive patients was also substantially higher for allergists than pulmonologists (32 vs. 8%, $p<0.001$).

Medication Use

Medication use varied modestly between the two groups depending on asthma severity (Table 4). Overall, daily use of a short-acting beta-agonist was higher in pulmonary patients (73–76% vs. 48–67%, $p<0.05$) irrespective of asthma severity. Among patients with mild to moderate asthma, use of a leukotriene modifier was higher in allergy patients (57 vs. 49%, $p=0.006$). Among patients with severe asthma, use of systemic corticosteroids was significantly greater in the pulmonary group (34 vs. 27%, $p=0.004$). Overall, use of long-acting beta-agonist without corticosteroids was low, whereas use of inhaled corticosteroid use was high. Although statistically significant differences between groups were found, the differences were relatively minor.

When patients with a concomitant diagnosis of emphysema or COPD were excluded, daily use of a short-acting beta-agonist remained higher for pulmonary patients with mild to moderate asthma, but differences in short-acting beta-agonist use among patients with severe asthma were no longer significant. Greater use of systemic corticosteroids in pulmonary patients with severe asthma remained significant despite excluding patients with emphysema or COPD.

Healthcare Utilization and Productivity Loss

Patients treated by pulmonologists reported greater healthcare utilization in the past 3 months than those treated by allergists (Table 5). Pulmonary patients were also more likely to report missed work or school in the past 2 weeks, as well as history of intubation. Unscheduled office visits, however, were not significantly different between the two groups. All results remained significant despite multivariate adjustment for demographic differences between the groups.

DISCUSSION

In this study, we analyzed cross-sectional data from a large cohort of patients with severe or difficult-to-treat asthma recruited from subspecialty practices across the United States. We found that pulmonary patients differed from allergy patients in several important ways. Most notably, patients treated by pulmonologists were more severe, as indicated by physician-assessment, GINA classification, lung function, and asthma control. Pulmonologists cared for a greater proportion of black patients, as well as patients of lower socioeconomic status. Evidence of allergic disease was prevalent in both subspecialties; however, use of skin testing and immunotherapy was substantially greater among allergy treated patients. Differences in medication use and healthcare utilization were reflective of greater asthma severity among pulmonary patients. Taken as a whole, these findings indicate that allergists and pulmonologist care for different segments of the asthma population, and that such differences should be taken into consideration when attempting to understand variations in practice patterns and outcomes.

Our results add to a growing body of literature on specialty care for asthma. While many studies have compared asthma specialists to generalists,^{1–7} few provide direct comparisons between subspecialties. In this study, we examined a broad array of differences between allergy and pulmonary patients, including demographic factors, asthma characteristics, medication use, and healthcare utilization, allowing us to consider ways in which these differences are likely to be interrelated. In contrast to studies that rely on databases restricted to a specific healthcare organization or geographic region,^{1,2,6,11,12} the current analysis benefits from the use of data from a nationwide, multicenter study (>230 sites) that incorporates patients from a diversity of practice settings, insurance plans, and locations.

While our findings point toward the fact that pulmonary patients generally have more severe asthma than allergy patients, this could reflect a number of factors. A particularly influential factor may relate to differences in subspecialty referral patterns. Since pulmonologists are often associated with managing chronic lung disease, asthma patients with worse lung function may be preferentially referred to pulmonologists. Our data support this notion insofar as we found lower FEV₁ and greater evidence of persistent airflow obstruction in the pulmonary group. This observation remained significant even after excluding patients with emphysema or COPD. Low FEV₁ and persistent airflow obstruction can be found in patients with persistently uncontrolled asthma (with or without airway remodeling present), but may also represent patients with mixed airway disease, for example asthmatic patients with an underlying component of COPD. Differentiating such patients can be difficult in a clinical setting, and even more so in the context of an epidemiologic study. Our results are significant only to the extent that such patients, as a whole, are more likely to be cared for by a pulmonologist.

Demographic variation between subspecialty patients may have also contributed to observed differences in asthma severity. Compared to allergy patients, pulmonary patients were more likely to be black, reported lower educational level, and were from lower income neighborhoods. Pulmonologists also cared for a significantly greater proportion of patients without private insurance. Several of these factors have been linked to worse asthma-related health.^{23–27} One potential explanation for these differences could be that pulmonary practices are more often affiliated with large, urban medical centers. We investigated this hypothesis, and found that both pulmonary and allergy sites in TENOR were equally likely to be located in urban areas, but that pulmonary practices tended to be in neighborhoods associated with greater racial/ethnic diversity and lower median income than allergy practices. Nonetheless, even after adjusting for differences in racial composition by site location, we found that pulmonologists were still more likely to treat black patients than allergists.

Variation in asthma management between the two subspecialties were also observed. Overall, pulmonary patients were more likely to require daily use of a short-acting beta-agonist, and if severe, were more likely to be treated with oral corticosteroids. Although we stratified our analyses by asthma severity, gradations of severity within each strata are likely to exist contributing the observed differences in medication use. Data from other investigators have shown similar findings. Diette et al. studied asthma treatment in 6,612 managed care members and found that use of inhaled beta-agonists was more frequent in patients of pulmonologists compared to allergists or generalists.⁸ Another study by Blanc et al. among 601 patients with predominantly mild to moderate asthma found greater use of high-dose inhaled corticosteroids in pulmonary patients as compared to allergy patients.⁹

As might be expected, patients treated by allergists were more likely to have been skin tested than those treated by pulmonologists. Due to the study design, it was not possible to ascertain exactly who ordered or performed the skin test. Nearly two-thirds of pulmonary patients in this study had skin testing performed, suggesting concomitant or previous care by allergy subspecialist. At certain institutions, a formal allergy referral may be required to perform skin testing. Alternatively, some patients skin tested by an allergist may be subsequently referred to a pulmonologist, especially if their asthma is unresponsive to treatment for allergic disease. Interdisciplinary care is likely to be common in patients with severe or difficult-to-treat asthma, making it difficult to distinguish the effects of isolated subspecialty care. Despite the potential overlap, we still found that patients with a positive skin test who were treated by a pulmonologist were less likely to receive immunotherapy than those treated by an allergist.

Due to the observational nature of the data, this analysis has other limitations. Observed variations in practice patterns should be interpreted with caution. While our findings suggest that allergists are much more likely to perform skin testing and immunotherapy, such results could be biased by the fact that atopic patients may be selectively referred to allergists. In a survey study by Li et al., generalists preferred allergists when referring asthma patients for an allergy evaluation or immunotherapy.²⁸ Likewise, patients with worse lung function or evidence of fixed airway disease may be preferentially referred to pulmonary subspecialists, as discussed above, influencing their subsequent management.

Although we also observed evidence of higher healthcare utilization and productivity loss in pulmonary patients, causality cannot be inferred. Furthermore, the need for more frequent healthcare does not necessarily imply a worse outcome, and may, in fact, reflect appropriate care. Nonetheless, similar differences in healthcare utilization by subspecialty have been reported by other investigators.^{9,12} Because such findings could be confounded by race, socioeconomic status, and insurance status, we included these factors in our multivariate analyses. Despite taking demographic differences into account, we found that pulmonary patients were still more likely to report healthcare utilization for asthma in the past 3 months compared to allergy patients.

By design, the majority of patients in TENOR had difficult-to-treat disease. In spite of the increased homogeneity of the study population, we were still able to detect important differences between the two subspecialties. While the inclusion criteria may limit the generalizability of our results, patients with difficult-to-treat disease are particularly relevant to the given research question in that they represent the population most often treated by subspecialists.

Since we chose to focus on subspecialty care in an adult population, our results are not generalizable to asthma in younger populations (age <18). Although the mean age of subjects in TENOR was 49, this should not be considered representative of asthma in the general population. Previous studies comparing specialist to generalist care for asthma, have shown that patients treated by specialists are significantly older. Furthermore, patients with higher healthcare utilization, as characterized by the TENOR cohort, are also more likely to be older in age.

In conclusion, we found that significant differences in asthma characteristics exist between allergy and pulmonary subspecialists. Our findings suggest that subspecialty practice patterns may be linked to underlying differences in demographics, asthma severity, and atopic disease, and thus should be taken into consideration in the design and interpretation of future epidemiologic studies. Differences in atopic status between subspecialties may have important implications in terms of asthma management, in particular with regard to anti-IgE therapy.

Acknowledgments

The authors would like to thank Kara McLeod and Dave Miller from ICON Clinical Research (San Francisco, CA) for providing their statistical expertise. The TENOR study was sponsored by Genentech, Inc. and Novartis Pharmaceutical Corp. This analysis was funded in part by an unrestricted fellowship grant to the University of California San Francisco from Genentech, Inc.

ABBREVIATIONS

ATAQ	Asthma Therapy Assessment Questionnaire
BMI	body mass index

COPD	chronic obstructive pulmonary disease
FEV₁	forced expiratory volume in 1 second
FVC	forced vital capacity
GINA	Global Initiative for Asthma
ICS	inhaled corticosteroid
LABA	long-acting beta-agonist
LTM	leukotriene modifier
OR	odds ratio
TENOR	The Epidemiology and Natural History of Asthma: Outcomes and Treatment Regimens

REFERENCES

1. Zeiger RS, Heller S, Mellon MH, Wald J, Falkoff R, Schatz M. Facilitated referral to asthma specialist reduces relapses in asthma emergency room visits. *J Allergy Clin Immunol.* 1991; 87(6): 1160–1168. [PubMed: 2045618]
2. Vollmer WM, O'Hollaren M, Ettinger KM, et al. Specialty differences in the management of asthma. A cross-sectional assessment of allergists' patients and generalists' patients in a large HMO. *Arch Intern Med.* 1997; 157(11):1201–1208. [PubMed: 9183231]
3. Vilar ME, Reddy BM, Silverman BA, et al. Superior clinical outcomes of inner city asthma patients treated in an allergy clinic. *Ann Allergy Asthma Immunol.* 2000; 84(3):299–303. [PubMed: 10752913]
4. Wu AW, Young Y, Skinner EA, et al. Quality of care and outcomes of adults with asthma treated by specialists and generalists in managed care. *Arch Intern Med.* 2001; 161(21):2554–2560. [PubMed: 11718586]
5. Kanter LJ, Siegel CJ, Snyder CF, Pelletier EM, Buchner DA, Goss TF. Impact of respiratory symptoms on health-related quality of life and medical resource utilization of patients treated by allergy specialists and primary care providers. *Ann Allergy Asthma Immunol.* 2002; 89(2):139–147. [PubMed: 12197569]
6. Schatz M, Cook EF, Nakahiro R, Petitti D. Inhaled corticosteroids and allergy specialty care reduce emergency hospital use for asthma. *J Allergy Clin Immunol.* 2003; 111(3):503–508. [PubMed: 12642829]
7. Storms B, Olden L, Nathan R, Bodman S. Effect of allergy specialist care on the quality of life in patients with asthma. *Ann Allergy Asthma Immunol.* 1995; 75(6 Pt 1):491–494. [PubMed: 8603278]
8. Diette GB, Wu AW, Skinner EA, et al. Treatment patterns among adult patients with asthma: factors associated with overuse of inhaled beta-agonists and underuse of inhaled corticosteroids. *Arch Intern Med.* 1999; 159(22):2697–2704. [PubMed: 10597760]
9. Blanc PD, Katz PP, Henke J, Smith S, Yelin EH. Pulmonary and allergy subspecialty care in adults with asthma. Treatment, use of services, and health outcomes. *West J Med.* 1997; 167(6):398–407. [PubMed: 9426478]
10. Blanc PD, Trupin L, Earnest G, et al. Effects of physician-related factors on adult asthma care, health status, and quality of life. *Am J Med.* 2003; 114(7):581–587. [PubMed: 12753882]
11. Erickson S, Tolstykh I, Selby JV, Mendoza G, Iribarren C, Eisner MD. The impact of allergy and pulmonary specialist care on emergency asthma utilization in a large managed care organization. *Health Serv Res.* 2005; 40(5 Pt 1):1443–1465. [PubMed: 16174142]
12. Schatz M, Zeiger RS, Mosen D, et al. Improved asthma outcomes from allergy specialist care: a population-based cross-sectional analysis. *J Allergy Clin Immunol.* 2005; 116(6):1307–1313. [PubMed: 16337464]

13. Dolan CM, Fraher KE, Bleecker ER, et al. Design and baseline characteristics of the epidemiology and natural history of asthma: Outcomes and Treatment Regimens (TENOR) study: a large cohort of patients with severe or difficult-to-treat asthma. *Ann Allergy Asthma Immunol.* 2004; 92(1):32–39. [PubMed: 14756462]
14. Vollmer WM, Markson LE, O'Connor E, et al. Association of asthma control with health care utilization and quality of life. *Am J Respir Crit Care Med.* 1999; 160(5 Pt 1):1647–1652. [PubMed: 10556135]
15. Vollmer WM, Markson LE, O'Connor E, Frazier EA, Berger M, Buist AS. Association of asthma control with health care utilization: a prospective evaluation. *Am J Respir Crit Care Med.* 2002; 165(2):195–199. [PubMed: 11790654]
16. Miller MK, Johnson C, Miller DP, Deniz Y, Bleecker ER, Wenzel SE. Severity assessment in asthma: An evolving concept. *J Allergy Clin Immunol.* 2005; 116(5):990–995. [PubMed: 16275365]
17. Liard R, Leynaert B, Zureik M, Beguin FX, Neukirch F. Using Global Initiative for Asthma guidelines to assess asthma severity in populations. *Eur Respir J.* 2000; 16(4):615–620. [PubMed: 11106201]
18. Standardization of Spirometry, 1994 Update. American Thoracic Society. *Am J Respir Crit Care Med.* 1995; 152(3):1107–1136. [PubMed: 7663792]
19. Haselkorn T, Borish L, Miller DP, Weiss ST, Wong DA. High prevalence of skin test positivity in severe or difficult-to-treat asthma. *J Asthma.* 2006; 43(10):745–752. [PubMed: 17169826]
20. Borish L, Chipps B, Deniz Y, Gujrathi S, Zheng B, Dolan CM. Total serum IgE levels in a large cohort of patients with severe or difficult-to-treat asthma. *Ann Allergy Asthma Immunol.* 2005; 95(3):247–253. [PubMed: 16200815]
21. Global strategy for asthma management and prevention. National Heart, Lung, and Blood Institute, National Institutes of Health; Bethesda, MD: 1995. Global Initiative for Asthma. (updated 2005). NIH publication no. 95-3659
22. Lee JH, Haselkorn T, Borish L, Rasouliyan L, Chipps BE, Wenzel SE. Risk factors associated with persistent airflow limitation in severe or difficult-to-treat asthma: insights from the TENOR study. *Chest.* 2007; 132(6):1882–1889. [PubMed: 18079222]
23. Stingone JA, Claudio L. Disparities in the use of urgent health care services among asthmatic children. *Ann Allergy Asthma Immunol.* 2006; 97(2):244–250. [PubMed: 16937759]
24. Grant EN, Lyttle CS, Weiss KB. The relation of socioeconomic factors and racial/ethnic differences in US asthma mortality. *Am J Public Health.* 2000; 90(12):1923–1925. [PubMed: 11111268]
25. Smith LA, Hatcher-Ross JL, Wertheimer R, Kahn RS. Rethinking race/ethnicity, income, and childhood asthma: racial/ethnic disparities concentrated among the very poor. *Public Health Rep.* 2005; 120(2):109–116. [PubMed: 15842111]
26. Boudreaux ED, Emond SD, Clark S, Camargo CA Jr. Acute asthma among adults presenting to the emergency department: the role of race/ethnicity and socioeconomic status. *Chest.* 2003; 124(3):803–812. [PubMed: 12970001]
27. Gupta RS, Carrion-Carire V, Weiss KB. The widening black/white gap in asthma hospitalizations and mortality. *J Allergy Clin Immunol.* 2006; 117(2):351–358. [PubMed: 16461136]
28. Li JT, Sheeler RD, Offord KP, Patel AM, Dupras DM. Consultation for asthma: results of a generalist survey. *Ann Allergy Asthma Immunol.* 1999; 83(3):203–206. [PubMed: 10507263]

FIGURE 1. Skin testing and immunotherapy by subspecialty

*Percent of subjects with positive skin test result among those tested (n=2,443) † Percent of subjects who reported receiving immunotherapy among those with positive skin test results (n=1,408) In all cases, $p < 0.0001$ for comparisons between subspecialties

Table 1

Baseline demographics for 3,342 adult subjects from TENOR

	All subjects (n=3,342)	Subspecialty		p value
		Pulmonary (n=935)	Allergy (n=2,407)	
Age, mean $\pm$ SD	48.9 $\pm$ 14.9	50.0 $\pm$ 15.8	48.5 $\pm$ 14.5	0.01
Female, n (%)	2,368 (71%)	686 (73%)	1,682 (70%)	0.05
Race/ethnicity, n (%)				<0.001
White	2,680 (80%)	707 (76%)	1,973 (82%)	
Black	378 (11%)	148 (16%)	230 (10%)	
Hispanic	176 (5%)	49 (5%)	127 (5%)	
Asian/Pacific Islander	55 (2%)	17 (2%)	38 (2%)	
Other	53 (2%)	14 (2%)	39 (2%)	
Smoking status, n (%)				0.35
Never	2,137 (64%)	580 (62%)	1,557 (65%)	
Past	1,065 (32%)	313 (33%)	752 (31%)	
Current	140 (4%)	42 (4%)	98 (4%)	
Body Mass Index, mean $\pm$ SD	30.4 $\pm$ 7.7	31.1 $\pm$ 8.4	30.1 $\pm$ 7.3	<0.001
Education, n (%)				<0.001
High school or less	950 (29%)	330 (36%)	620 (26%)	
Some college or trade school	1,116 (34%)	294 (32%)	822 (34%)	
College graduate or advanced deg.	1,254 (38%)	304 (33%)	950 (40%)	
Median household income, n (%) [*]				<0.001
<\$40,000	603 (19%)	229 (25%)	374 (16%)	
\$40,000 to < \$60,000	1,425 (44%)	395 (43%)	1,030 (44%)	
\$60,000 to < \$80,000	796 (25%)	176 (19%)	620 (27%)	
$\geq$ \$80,000	419 (13%)	116 (13%)	303 (13%)	
Health insurance, n (%)				<0.001
Commercial/PPO	1,468 (44%)	340 (37%)	1,128 (47%)	
HMO	913 (27%)	244 (26%)	669 (28%)	
Medicaid	174 (5%)	78 (8%)	96 (4%)	
Medicare	528 (16%)	194 (21%)	334 (14%)	
Other	240 (7%)	73 (8%)	167 (7%)	

^{*} Based on 2000 U.S. Census data for ZIP Code Tabulation Area (ZCTA) of subject's primary residence.

Table 2

Characteristics of TENOR study site locations

	Site Subspecialty		p value
	Pulmonary (n=81)	Allergy (n=155)	
Commuting area classification, n (%)			0.55
Urban core area	75 (94%)	147 (95%)	
Suburban area	1 (1.3%)	3 (1.9%)	
Large town area	3 (3.8%)	5 (3.2%)	
Small town and isolated rural area	1 (1.3%)	0 (0.0%)	
Local racial/ethnic composition [*] , mean percent $\pm$ SD			
White	65 $\pm$ 27%	78 $\pm$ 19%	<0.001
Black	21 $\pm$ 25%	11 $\pm$ 17%	<0.001
Hispanic	13 $\pm$ 17%	10 $\pm$ 14%	0.17
Asian/Pacific Islander	6 $\pm$ 8%	5 $\pm$ 5%	0.32
Other	6 $\pm$ 8%	4 $\pm$ 7%	0.14
Local median household income [*] , mean $\pm$ SD	48,506 $\pm$ 26,190	62,378 $\pm$ 30,160	<0.001

^{*} Racial/ethnic composition and median household income based on 2000 U.S. Census data for ZIP Code Tabulation Area of the study site.

Table 3

Differences in asthma-related health by subspecialty

	Subspecialty		p value
	Pulmonary (n=935)	Allergy (n=2,407)	
Age at diagnosis, mean $\pm$ SD	25.9 $\pm$ 20.2	24.7 $\pm$ 18.8	0.12
Physician-assessed severity			<0.001
Mild	34 (4%)	53 (2%)	
Moderate	365 (39%)	1,159 (49%)	
Severe	530 (57%)	1,177 (49%)	
Classified as 'difficult-to-treat' by physician*	885 (95%)	2,268 (95%)	0.70
GINA classification			<0.001
Mild	21 (2%)	62 (3%)	
Moderate	274 (31%)	1,003 (43%)	
Severity	603 (67%)	1,265 (54%)	
FEV ₁ percent predicted, mean $\pm$ SD	71 $\pm$ 25%	75 $\pm$ 23%	<0.001
FEV ₁ percent predicted, n (%)			<0.001
$\geq$ 80%	309 (36%)	915 (41%)	
>60% to <80%	237 (28%)	747 (34%)	
$\leq$ 60%	305 (36%)	560 (25%)	
Persistent airflow obstruction [†]	176 (68%)	422 (57%)	0.002
ATAQ control index			<0.001
0 problems	116 (13%)	421 (18%)	
1 problem	161 (18%)	482 (21%)	
2 problems	265 (29%)	756 (32%)	
3+ problems	364 (40%)	697 (30%)	
Serum IgE level, IU/ml			
Geometric mean (95% confidence level)	74 (67–83)	88 (82–94)	0.009
Median	75	96	
Range	1–9,212	1–15,101	
Self-reported asthma triggers			
Pollen	618 (67%)	1,675 (70%)	0.06
Pets or animals	427 (46%)	1,311 (55%)	<0.001
Moldy, musty, or damp places	553 (60%)	1,512 (63%)	0.06
Dust	721 (78%)	1,893 (79%)	0.40
Cold air	659 (71%)	1,782 (75%)	0.05
Change in weather	708 (77%)	1,704 (71%)	0.003
Tobacco smoke	701 (76%)	1,766 (74%)	0.28
Indoor irritants (e.g., carpets, stove, pillows)	376 (41%)	953 (40%)	0.70
Emotional stress	581 (63%)	1,478 (62%)	0.63
Exercise	729 (79%)	1,920 (80%)	0.30
Aspirin	127 (14%)	325 (14%)	0.93
Co-morbid conditions			

	Subspecialty		p value
	Pulmonary (n=935)	Allergy (n=2,407)	
Allergic rhinitis	520 (56%)	1,855 (78%)	<0.001
Atopic dermatitis	120 (13%)	331 (14%)	0.59
Emphysema or COPD	136 (15%)	149 (6%)	<0.001
History of pneumonia	606 (65%)	1,384 (58%)	<0.001
GERD	98 (11%)	284 (12%)	0.28

Reported p values based on t test for continuous variables, Chi-square test for categorical variables, and Chi-square test for trend (Mantel-Haenszel) for ordinal variables.

* 'Difficult-to-treat' defined as difficulty adhering to the regimen, requirement for multiple drugs, inability to avoid triggers, frequent or severe exacerbations, or unresponsiveness to therapy. Subjects classified as difficult-to-treat could be categorized as either mild, moderate, or severe.

[†] 'Persistent airflow obstruction' defined as post-bronchodilator FEV1/FVC ratio of $\leq 70\%$ on at least two visits 12 months apart.

Table 4

Asthma medication use by subspecialty

	Mild to moderate asthma *		p value	Severe asthma *		p value
	Pulmonary (n=399)	Allergy (n=1,212)		Pulmonary (n=530)	Allergy (n=1,177)	
Short-acting beta-agonist			<0.001			0.04
Intermittent use (less than once daily)	91 (24%)	602 (52%)		129 (28%)	364 (33%)	
Regular use (daily use)	280 (76%)	561 (48%)		340 (73%)	749 (67%)	
Long-acting beta-agonist (LABA)						
LABA use	305 (77%)	912 (75%)	0.43	429 (82%)	961 (82%)	0.75
LABA use without inhaled corticosteroid	11 (3%)	19 (2%)	0.12	18 (3%)	17 (1%)	0.008
Inhaled corticosteroid (ICS)						
ICS use	374 (95%)	1,162 (96%)	0.32	497 (94%)	1,132 (97%)	0.02
ICS use without long-acting beta agonist	80 (20%)	269 (22%)	0.42	86 (16%)	188 (16%)	0.89
LABA and ICS use	294 (74%)	893 (74%)	0.77	411 (78%)	944 (80%)	0.21
Leukotriene modifier (LTM)						
LTM use	194 (49%)	691 (57%)	0.006	318 (60%)	729 (62%)	0.46
LTM use without LABA or ICS	2 (<1%)	19 (2%)	0.11	6 (1%)	13 (1%)	0.96
Mast cell stabilizer	13 (3%)	48 (4%)	0.55	28 (5%)	56 (5%)	0.64
Methylxanthine	50 (13%)	147 (12%)	0.78	104 (20%)	269 (23%)	0.14
Total number of long-term controllers						0.53
0	7 (2%)	9 (1%)	0.17	3 (1%)	6 (1%)	
1	34 (9%)	93 (8%)		30 (6%)	63 (5%)	
2	173 (44%)	503 (42%)		176 (34%)	352 (30%)	
3+	181 (46%)	607 (50%)		317 (60%)	748 (64%)	
Systemic corticosteroids	50 (13%)	138 (11%)	0.49	179 (34%)	317 (27%)	0.004

* Physician-assessed asthma severity. All mild to moderate patients were also considered difficult-to-treat by their asthma provider. See Table 3 for definition of 'difficult-to-treat'.

Table 5

Association between physician subspecialty and asthma-related healthcare utilization and productivity loss

Health outcome	Unadjusted			Adjusted		
	OR	(95% CI)	p value	OR	(95% CI)	p value
Steroid burst	1.34	(1.15, 1.56)	<0.001	1.33	(1.14, 1.55)	<0.001
Unscheduled office visit	1.10	(0.94, 1.28)	0.24	1.08	(0.92, 1.26)	0.35
Emergency room visit	2.01	(1.64, 2.46)	<0.001	1.91	(1.54, 2.37)	<0.001
Hospitalization	3.19	(2.33, 4.37)	<0.001	2.89	(2.08, 4.03)	<0.001
Ever intubated	1.74	(1.40, 2.15)	<0.001	1.63	(1.31, 2.03)	<0.001
Missed work/school	1.47	(1.12, 1.94)	0.005	1.51	(1.14, 1.99)	0.004

Odds ratios expressed for Pulmonary versus Allergy [referent]

Analyses adjusted for age, gender, race, education, median neighborhood income, and insurance status.

Steroid burst, unscheduled office, emergency room visit and hospitalization refer to past 3 months.

Missed work/school refers to past 2 weeks.