
Health care costs of allergic rhinitis-associated conditions vary with allergy season

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Background: Studies have documented how allergic respiratory symptoms vary with allergen levels, but the impact of allergen levels on health care expenditures for allergy-related conditions has never been shown using actual data on outdoor allergen levels. Evidence linking respiratory allergy to comorbid conditions has also been scanty.

Objective: To investigate the link between respiratory allergy and presumably associated conditions by documenting seasonal patterns in their severity and co-occurrence, and to suggest a plan for future research.

Methods: A retrospective, cross-sectional analysis of medical claims data from 1995 to 1996 were linked to monthly data from federal counting stations on outdoor allergen levels. Participants were employed persons and their dependents, living within 15 miles of an allergen-counting station, continuously enrolled in a health plan for 1995 and 1996, and identified through medical claims data as having asthma, allergic rhinitis (AR), migraines, sinusitis, tonsillitis, otitis media, depression, or anxiety disorder.

Results: All conditions studied were more likely to occur during allergy season than during nonallergy season. For persons with health care claims for a condition of interest in both seasons, total health care costs during allergy season were significantly higher than during nonallergy season. Predicted condition-related expenditures were higher in allergy season for every condition even after controlling for the effect of AR.

Conclusion: Allergy effects appear to extend beyond AR symptoms. Other conditions may be affected by outdoor allergen levels even in the absence of AR symptoms, implying that these conditions may be etiologically related to allergy, irrespective of their co-existence with allergic rhinitis, further implying that allergic sensitization can independently affect different parts of the respiratory tract as well as the brain.

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INTRODUCTION

Respiratory allergies affect at least 20% of the United States population and are the sixth leading cause of chronic illness.¹ Seasonal allergic rhinitis is found in 35 to 40 million Americans each year, sinusitis in 31 million, and asthma in 17 million,^{2–5} and their prevalence is growing.^{6,7} The total burden of allergy-related conditions in the United States exceeds \$10 billion per year in medical expenses and lost productivity.^{5,8}

A full accounting of the economic impact of allergic rhinitis (AR) must also consider that it may exacerbate certain comorbid conditions, leading to additional direct and indirect expenditures. The link between comorbid conditions and AR may be because of the outdoor allergen levels causing allergic reactions that directly affect the relevant target organs, to local or systemic consequences of AR, or to a combination of the two.^{9,10} If allergen levels directly effect target organs involved in a given condition, the prevalence of that condition should increase during periods of time where high allergen levels are recorded. Outdoor allergens may also impact severity, with or without a change in disease prevalence. If

the link is attributable to the local or systemic effects of AR rather than allergens, AR may serve as a predisposing factor for the comorbid conditions. Beyond prevalence, AR could also affect the severity of the conditions.

In this study we provide evidence on the relation of comorbid conditions to outdoor allergen levels while controlling for the presence of AR and illustrate how variations in allergen levels affect health care spending for these conditions. Seven conditions were chosen based upon an observed or theorized relationship to AR: anxiety disorder, asthma, depression, migraine, otitis media, sinusitis, and tonsillitis. AR is highly comorbid with asthma.^{5,8,11–13} Studies have found asthma in 19 to 38% of people with a history of AR but only 3 to 5% of the general population.^{14,15} As many as 78% of patients with asthma report nasal allergy symptoms, well above the 20% rate in the general population.^{14,16} Further, treatments that relieve nasal symptoms of AR and asthma also improve the pulmonary symptoms of allergic asthma.¹⁷ AR has been linked to many other illnesses as well. Among patients with sinusitis and comorbid AR, a worsening of symptoms during allergy season is noted.¹⁸ Acute sinusitis frequently occurs as a complication of AR, and the paranasal sinuses have been shown to develop mucosal alterations after experimental nasal allergy exposure.¹⁹ Otitis media is a recognized complication of AR,²⁰ although AR alone is not sufficient to produce otitis media.⁸ Relative to the general pediatric population, children ages 3 to 6 years old with AR are at least three times more likely to have otitis media with

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effusion.⁸ Tonsillitis has been linked to AR and other upper respiratory illnesses, particularly as a predisposing factor for sinusitis.²¹ The inflammatory mediator leukotriene causes symptoms of AR and seems to play a role in the onset of migraine headaches.²² There is also evidence linking allergic conditions to mental health conditions.²³ AR has been found to be associated with higher rates of depression and anxiety disorder and to increased mental-health-related outpatient expenditures.²³

METHODS

Data and Analytic Sample

Data for this study were extracted from The MEDSTAT Group’s MarketScan database for calendar years 1995 and 1996 and included paid claims for inpatient services outpatient services, and outpatient prescription drugs.²⁴ The database represents the health care experiences of persons employed in large companies or organizations and the covered dependents of those employees. In general, the plans are operated as indemnity-type or preferred provider organization programs. In addition to information on diagnoses, procedures, providers, and site of care, positive enrollment data are available for a subset of the MarketScan population.

Weekly outdoor allergen data for 1995 through 1996 were obtained from Surveillance Data Incorporated (SDI). SDI collected information on allergen levels from 50 stations in the United States during the months of February through November. Data were not collected during December and January because of safety concerns and the extremely low winter allergen levels in many states. The data used for this study contained a rating of the level of the predominant outdoor allergens (trees, grasses, weeds, or molds) in each of the 50 areas during a given week. The allergen level was rated as absent, low, moderate, high, or very high based upon the actual predominant allergen in the area for that week.

Study Population

The study population was limited to persons who lived within a 15-mile radius of one of the allergen-counting stations, were continuously enrolled in the same health plan from 1995 through 1996, and had data available on prescription drug use. Persons with evidence of AR or any of the seven conditions expected to be comorbid with AR were identified using this subset of MarketScan data. The algorithms for identifying people with the conditions of interest were developed in conjunction with clinical experts based from diagnosis codes and National Drug Codes (Table 1). After applying these algorithms, we aggregated each patient’s inpatient, outpatient, and prescription drug health care claims for the years 1995 and 1996.

The temporal and geographic nature of the allergen count data enabled us to use empirical evidence on allergen levels to define allergy and nonallergy seasons for specific locations. For each area we defined periods of time when outdoor allergens were absent or low and periods when they was moderate, high, or very high. Allergy season was defined as the period in which there was moderate to very high outdoor allergen counts in the area. Nonallergy season was during periods when the same allergens were absent or low in the given area. In specifying allergy and nonallergy seasons for the defined areas, we established criteria for computing the total duration (in months) of the seasons over the 2-year period. The duration variables for each season were then merged to the patient-level file using the patient’s zip code.

Analytical Approach

We first calculated incidence rates for each condition based on the entire study population. Separate rates were derived for allergy and nonallergy seasons to illuminate how variation in outdoor allergen levels affects incidence. By dividing the allergy season rate by the nonallergy season rate, we deter-

Table 1. Inclusion and Exclusion Criteria for Identifying Conditions of Interest¹

Condition	Inclusions: diagnosis codes	Inclusions: drug classes	Exclusions: diagnosis codes
Migraine	346, 346.0, 346.1, 346.8, 346.9, 307.81	Caffeine, ergotamine tartrate, methysergide maleate, sumatriptan succinate	
Asthma	493		COPD, chronic bronchitis ²
Depression	296.20–296.23, 296.25–296.26, 296.30–296.33, 300.4, 309, 309.1, 311		
Anxiety disorder	300, 300.01–300.03, 300.09, 300.20–300.23, 300.29, 308, 309.24, 309.81		
Sinusitis	461.0–461.9, 473.0–473.99		
Tonsillitis	34.0, 463, 474.0, 475		
Otitis media	55.2, 381.0–381.09, 382.0–382.09		
AR	477	Nonsedating antihistamines, nasal inhaled steroids	

¹ In some cases multiple prescriptions or a combination of diagnoses and prescriptions were required. Details are available from the corresponding author+A8.

² Condition names shown for clarity. COPD, chronic obstructive pulmonary disease.

mined incidence rate ratios. If the corresponding 95% confidence interval does not bracket the value 1.0, we may conclude that the conditions are more (or less) common during times of high allergen counts.

Severity of illness was measured by health care payments for the conditions under the assumption that greater severity leads to higher payments. Individuals with each condition of interest were then categorized into three mutually exclusive groups based upon when they used health care services for the given condition: in allergy season only, in nonallergy season only, or in both seasons. The expenditure analysis was conducted on the subsample having utilization for the condition of interest in *both* allergy and nonallergy seasons. This enabled us to compare individuals' disease-specific health care expenditures in allergy season to their expenditures for that condition during nonallergy season.

Monthly outpatient, inpatient, drug, and total expenditures for the period 1995 to 1996 were analyzed. Condition-related expenditures refer to health care spending for the specific conditions of interest. Claims for condition-related payments were identified through procedure codes, diagnosis codes, and National Drug Codes indicative of each condition of interest (Table 1). We then categorized payments as belonging to allergy season or nonallergy season. The expenditure measures were constructed on a monthly basis because the seasons varied in length across counting stations.

To control for the impact of covariates, we estimated multivariate regression models of mean monthly health care payments in allergy and nonallergy seasons for each condition and expenditure measure (outpatient, drug, and total). The parameter estimates were used to predict disease-specific payments in each season separately, controlling for covariates. Covariates in our analyses included the patient's sex, age, region of residence (south, west, northeast, or north central), and relationship to the insured employee (employee, spouse/dependent). We also included a proxy for overall health status, measured as the number of unique ICD-9-CM diagnoses received over the 2-year period. Paired *t*-tests were computed to test for differences in predicted payments between allergy and nonallergy seasons.

Specification of the Multivariate Models

The multivariate analysis follows recent advances in the specification of statistical models of health care expenditures. These models are typically estimated with log-transformed dollars as the outcome variable.^{25,26} Researchers routinely retransform the resulting coefficients (from log-dollars to dollars) by incorporating a "smearing" term into the retransformation.²⁷ Yet, this method is unbiased only if the errors in the equation do not vary systematically with any of the confounding factors, an uncommon situation in practice.²⁸ We therefore modeled mean monthly expenditures using an exponential conditional mean specification, an appropriate choice for nonnegative outcomes, such as payments.²⁸ Because the outcome variable is measured in dollars, the exponential conditional mean model avoids the retransformation difficulty that plagues log-transformed models. Parameter estimates were obtained through the method of nonlinear least squares.

RESULTS

There were 40,188 individuals in the final study sample with at least one condition of interest. The number of people with health care utilization for each condition is presented in Table 2, disaggregated by when the claims were incurred. At least 50% of all sample patients had claims in both allergy and nonallergy seasons for 6 of the 8 conditions of interest.

Incidence rates for each condition are reported in Table 3. They represent the proportion of individuals having pharmacy or medical claims indicating the presence of each condition. Incidence rate ratios were calculated to compare the rates in allergy and nonallergy seasons. The incidence of all conditions was significantly higher ($P < 0.05$) in allergy season, in some cases twice as high. Although this finding is unexceptional for conditions directly related to allergens, such as AR and asthma, there was also strong seasonality in the likelihood of having medical claims for migraine, depression, and anxiety.

To determine whether the observed seasonality was an artifact of the analytic file rather than a true clinical pattern, we calculated incidence rates of two conditions presumed to be unrelated to AR: bladder infection and inguinal hernia. We

Table 2. Number of People with Health Care Utilization For Each Condition of Interest by When Claims Were Incurred

Condition	Total number in sample		Allergy season only	Nonallergy season only		Both seasons
	Number	%	Number	Number	%	Number
Total Sample	40,188					
Migraine	1,687	4.20	290	955	56.61	442
Asthma	9,154	22.78	657	3,526	38.52	4,971
Depression	10,173	25.31	355	2,239	22.01	7,579
Anxiety disorder	2,659	6.62	216	917	34.49	1,526
Sinusitis	13,681	34.04	672	5,742	41.97	7,267
Tonsillitis	4,758	11.84	272	2,200	46.24	2,286
Otitis media	2,918	7.26	164	1,149	39.38	1,605
AR	17,101	42.55	1,507	5,679	33.21	9,915

Table 3. Incidence Rates per 1,000 Person Months, Selected Conditions, and Allergy and Nonallergy Seasons

Condition	Incidence rate during allergy season	Incidence rate during nonallergy season	Incidence rate ratio	
			Rate	
Migraine	67.94	47.02	1.44	1.58
Asthma	97.62	52.44	1.86	1.93
Depression	121.92	54.83	2.22	2.29
Anxiety disorder	102.69	52.14	1.97	2.10
Sinusitis	92.85	53.57	1.73	1.78
Tonsillitis	87.87	52.73	1.67	1.75
Otitis media	93.19	53.95	1.73	1.83
AR	108.41	51.12	2.12	2.17

found that these conditions did not occur more frequently in allergy season. Of the 2,364 people with claims for urinary tract infection, 418 (17.7%) had claims in allergy season alone whereas 1,573 (66.5%) had claims only in nonallergy season. Inguinal hernia claims were found for 279 people, of whom 43 (15.4%) had them in allergy season alone and 181 (64.9%) had them only in nonallergy season. On this basis we conclude that the patterns of seasonality are not artifacts of the data collection and analysis.

Table 4 presents descriptive statistics for the study population used in the multivariate regression models. Only individuals with complete data for all analytic variables were included in the analyses. Patients had mean ages of 33 to 42 years except for otitis media (14.7) and tonsillitis (16.5), which have greater prevalence among children. Males were a minority of patients for every condition, from 19% of migraineurs to 43% of asthma patients. Southern states contributed 25 to 39% of all observations, Northeast states 7 to 17%, and Western states 5% to 8%. (The reference category, Central states, accounted for 45 to 53% of all observations.) Among the conditions that primarily affect adults, approximately half of patients (42 to 58%) were covered employees, whereas the remainder were spouses, children, or other dependents. Employees were a much smaller proportion of otitis media patients (16%) and tonsillitis patients (18%), however. The mean number of unique diagnoses received during the study period ranged from 12.2 for otitis media patients to 18.1 for migraine patients. As expected, AR was most common among people with sinusitis (52%) or asthma

(50%). It was least common among those with anxiety (31%) or depression (31%).

Table 5 presents regression-adjusted mean condition-related expenditures in allergy and nonallergy seasons for patients with each condition. People who did not incur any services in either allergy season or nonallergy season for a given condition are not included in the expenditure calculations for that condition. Total disease-specific payments were uniformly higher in allergy season ($P < 0.01$), ranging from \$1.61/month higher for otitis media to \$17.82/month higher for anxiety disorder. Within each condition, spending during allergy season was typically higher in most or all categories than in nonallergy season (results not shown). For example, depression-related spending during allergy season was significantly higher for outpatient services (6.7%) and prescription drugs (7.0%). Similarly, health care spending for anxiety disorder rose by 15.1% in allergy season for outpatient services and 1.6% for prescription drugs.

There was also surprising evidence that outdoor allergens affect the conditions of interest even in the absence of AR. Using the regression coefficients derived earlier, we predicted total asthma-related expenditures for people having asthma-related claims in both seasons. To eliminate the impact of AR, we calculated the predicted expenditures as if AR had no impact on expenditures (ie, as if it had a regression coefficient of zero) and then compared predicted expenditures in allergy season to those in nonallergy season. If higher expenditures in allergy season are driven by AR, then after controlling for it, there should be no statistically significant

Table 4. Clinical and Demographic Characteristics of Condition-Specific Samples

Covariates	Anxiety N = 1,501	Asthma N = 4,849	Depression N = 7,436	Otitis media N = 1,573	Sinusitis N = 7,164	Tonsillitis N = 2,251
Age	40.21	33.27	42.43	14.72	34.09	16.46
Male (%)	34.97	42.79	32.89	45.77	36.81	41.89
Northeast (%)	17.02	10.44	8.34	8.20	7.30	7.37
South (%)	24.50	32.65	33.14	38.53	35.22	34.92
West (%)	6.38	5.44	5.82	5.66	5.40	4.53
Employee (%)	57.68	42.28	55.46	15.96	46.20	18.17
Diagnosis count	15.44	13.08	14.70	12.18	15.05	12.29
AR (%)	30.53	49.66	31.28	33.50	52.30	31.85

Table 5. Regression-Adjusted, Condition-Related Monthly Expenditures Allergy and Nonallergy Seasons¹

	Allergy season	Nonallergy season	Difference ²
Asthma	39.22	33.46	5.76
Depression	85.33	78.96	6.37
Anxiety disorder	94.55	76.73	17.82
Sinusitis	30.26	26.53	3.73
Tonsillitis	19.53	15.02	4.51
Otitis media	18.12	16.51	1.61
Migraine	63.53	41.48	22.05

¹ Sample consists of individuals with complete data for all analysis variables and who have claims for selected conditions in both allergy and nonallergy seasons.

² Values for allergy and nonallergy seasons were significantly different ($P < 0.01$ for all conditions).

difference in expenditures across seasons. Instead, we found that asthma expenditures were significantly higher during allergy season ($P < .01$, results not shown). A similar exercise was carried out for the six remaining conditions of interest other than AR. In each case, allergy-season expenditures were significantly higher ($P < 0.01$) than those in nonallergy season. The increment in expenditures during allergy season ranged from \$1.12 per month for asthma (3.7% of the nonallergy season level), to \$22.42 per month for anxiety (29.2%).

COMMENTS

This study investigated whether health care expenditures for seven major illnesses were associated with outdoor allergen levels. To our knowledge, this is the first study to link location-specific outdoor allergen counts to administrative data on individuals' health care use. Previous studies have relied on small samples or personal recall of sensitive, detailed information on health care use and expenditures. By linking scientific measurements of allergen counts to administrative claims data, we were able to circumvent both these problems.

There are several limitations to consider when interpreting the results presented in this paper. The allergen data reported by SDI represent an average weekly rating for the predominant type of outdoor allergen, which may or may not be the only allergen present in the given area. Individual sensitivity to different types of allergens varies and is not accounted for in this analysis. The data are measured at reporting stations rather than in the regions around the stations. Although the sample was limited to individuals living within a 15-mile radius of a reporting station, the allergen counts may not be accurate for every locality within that area because of geographic features or weather patterns. In addition, this study is subject to limitations faced by all retrospective analyses of claims data, notably the possibility of inaccurate coding of medical services and errors in transcription of medical records to discharge forms and claims records.

Additionally, it is important to consider the seasonal patterns associated with the conditions that we studied that may

be unrelated to pollen counts. For example, there is a recognized seasonality associated with depressive disorders and anxiety. Seasonal affective disorder is a condition that is characterized by recurrent episodes of depression in certain months of the year. Usually those affected by seasonal affective disorder become depressed in the fall and winter and feel better during the spring and summer. (Rosenthal NE, 1993) The observed increase in expenditures for anxiety and depression during allergy season may be related to the overlap in the seasonality of these conditions.

The findings presented here could be extended in several directions. AR may be a predisposing factor for the seven conditions studied. If so, the prevalence of these conditions in the population with AR should be higher than in the population without it. Several studies have supported the theory that AR is a predisposing factor for asthma, but most other allergy-related conditions have not been extensively investigated in this regard. The current literature does link AR to several of the illnesses discussed in this paper. As discussed earlier, sinusitis patients with comorbid AR experience a worsening of symptoms during allergy season.²³ There is also evidence linking AR to mental health conditions.²³ AR has been found to be associated with higher rates of depression and anxiety disorder and to increase mental health-related outpatient expenditures.²³ AR, is also a common comorbidity found in people suffering from migraines.²⁹ Although the relationship between migraine and the AR has not been extensively documented in the literature, Sibbald and Rink³⁰ observed that compared with those with seasonal AR, patients with perennial rhinitis were more likely to have past or current migraine. In addition, it has been found that the inflammatory mediator leukotriene causes symptoms of AR and seems to play a role in the onset of migraine headaches.³²

Further investigation is also needed to determine why allergy-season expenditures are higher for these conditions even when controlling for the impact of AR. Although some illnesses are known to vary by calendar season regardless of allergy status, such as depression, many others are not considered strongly seasonal. Careful clinical analysis of individual patients may be necessary to determine the cause of higher expenditures during allergy season.

We also hypothesize that when AR co-exists with any of these respiratory or mental conditions, it may act as an aggravating factor. If this is true, the severity of AR will parallel that of the other illnesses. Note that this will hold regardless of the reason for the co-existence of AR and the co-existing condition. Because a percentage of patients with AR suffer from perennial disease with seasonal exacerbations, they would provide a reference population for investigating similar seasonal patterns among the other conditions. The sample population would necessarily be limited to those with perennial AR who have increased claims during high-allergen season plus the relevant diagnosis for the co-existing condition. One would then track the expenditures for the other condition; if rhinitis acts as an aggravating factor, these expenditures will rise during high-allergen season.

Testing these hypotheses will require researchers to follow a large and medically diverse population over the course of many seasons. A combination of allergen data for relatively small areas will be needed, matched to administrative claims data for persons who reside there. The ability to gather information directly from patients would widen considerably the range of potential research topics. Although it is costly and time-consuming to develop comprehensive longitudinal databases, the high and growing prevalence of allergy-related illnesses suggest that the investment would be wise.

CONCLUSION

We found that individuals were significantly more likely to have claims for migraine, asthma, depression, anxiety disorder, sinusitis, tonsillitis, otitis media, and AR during allergy season than during nonallergy season. For the subset of persons having claims for a condition of interest in both seasons, total health care costs during allergy season were significantly higher than during nonallergy season. Further, the same result held even when we controlled for the presence of AR. A natural implication of this unexpected result is that the other conditions may be affected by outdoor allergen levels even in the absence of AR symptoms. A number of respiratory and mental conditions may be etiologically related to allergy, irrespective of their co-existence with AR, implying that allergic sensitization can independently affect different parts of the respiratory tract as well as the brain. If this is true, then in the absence of any evidence of AR, patients will experience a worsening of the condition during high-allergen season.

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