Clinical Communications

Drivers of health care costs for adults with persistent asthma

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Clinical Implications

- Global Initiative for Asthma step-care level 4 or 5, frequent asthma exacerbations, excessive rescue bronchodilator use, and elevated blood eosinophil count are among the independent cost predictors associated with increased asthma-related total health care costs for adults aged 18 to 64 years with persistent asthma.

TO THE EDITOR:

Yearly direct costs for adults with asthma from 2005 to 2009 were estimated at $59.7 billion in the United States.[1] Understanding the driving forces associated with direct costs of patients with asthma may guide efforts to reduce costs and/or prevent their future increase. In addition to the usual factors related to asthma and its costs, reports highlight that a high blood eosinophil count is an independent risk factor for increased current and future asthma exacerbations in adults[2-4] and children[5,6] with persistent asthma.

To identify the independent risk factors of direct costs in adults with persistent asthma, we conducted a retrospective study of a previously characterized adult cohort with persistent asthma enrolled in the Kaiser Permanente Southern California managed-care organization.[2] Administrative and health care utilization data and associated costs data were collected to determine predictors associated with direct all-cause health care total costs (referred to as "all-cause costs") and direct asthma-related health care costs (referred to as "asthma costs") (see Figure E1, *A*, in this article's Online Repository at www.jaci-inpractice.org).[4] The study cohort included 2392 patients aged 18 to 64 years with persistent asthma who met the Healthcare Effectiveness Data and Information Set (HEDIS) 2-year criteria for persistent asthma in 2009 and 2010 (see this article's Online Repository at www.jaci-inpractice.org for HEDIS definition, which includes all severities of persistent asthma and exclusions) and had a blood eosinophil determination in 2010 (Figure E1, *B*).[2]

The components of all-cause and asthma costs in 2011 (in 2014 US $) are detailed in this article's Online Repository at www.jaci-inpractice.org. Generalized linear models with gamma distribution and log-link function were used to estimate the direct all-cause and asthma costs as noted previously.[4] The adjusted marginal costs and 95% CIs of the predictors in 2010 were reported.[4] The predictive models included independent variables measured in 2010 as predictors (Figure 1 legend) and all-cause and asthma costs in 2011 as outcome variables.[2] The cost analyses were conducted with Stata 14 (StataCorp LP, College Station, Texas). All tests were 2-tailed with significance at alpha 0.05.

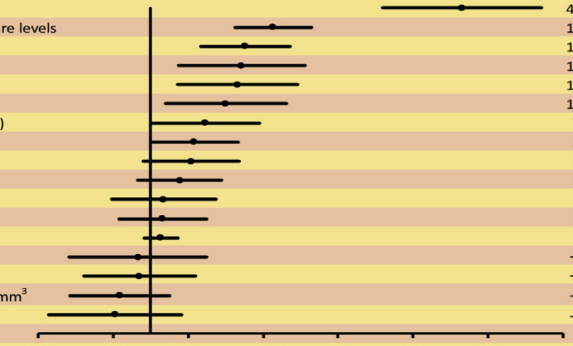
The unadjusted mean ± SD all-cause and asthma costs per patient were greater for the baseline year ($6556 ± $7834 and $2602 ± $2172, respectively) (see Table E1 in this article's Online Repository at www.jaci-inpractice.org) than for the outcome year ($5559 ± $7007 and $2277 ± $2241, respectively) (Table I), possibly representing improvement in asthma-targeted Kaiser Permanente Southern California intervention. The unadjusted total all-cause and asthma costs and many of its components were significantly greater for patients at Global Initiative for Asthma (GINA) step-care level 4 or 5 and 2 or more previous year asthma exacerbations compared with lower step-care levels and history of fewer exacerbations (Table I). Total asthma costs, but not all-cause costs, were significantly greater at higher eosinophil counts compared with lower eosinophil counts at cutoff points of 300 cells/mm^3 and 400 cells/mm^3 ($P < .01$ for both analyses) (see Table E2 in this article's Online Repository at www.jaci-inpractice.org).

After adjustment for covariates, the following predictors contributed to a significant increase in all-cause costs, in decreasing order: Charlson comorbidity index (CCI) 2 or more versus 0 ($4156); GINA step-care level 4 or 5 versus 1, 2, or 3 ($1633); females ($1262); pulmonologist visit ($1211); chronic oral corticosteroid (OCS) use, defined as 2.5 mg/d or more average cumulative daily dosage[7] ($1155); asthma medication ratio (AMR) 0.5 or more (see Online Repository) ($1001); and 7 or more short-acting β_2-agonist (SABA) canisters dispensed ($726) (Figure 1, *A*). The cost predictors significantly associated with total *asthma* costs, in decreasing order, were GINA step-care level 4 or 5 versus 1, 2, or 3 ($1226), AMR 0.5 or more ($869), 7 or more SABA canisters dispensed ($824), 2 or more asthma exacerbations ($602), chronic OCS use ($421), an allergist visit ($338), CCI 2 or more versus 0 ($334), blood eosinophil count 400 cells/mm^3 or more ($293), non-Hispanic ($288), and an age increase per every 10 years ($180) (Figure 1, *B*). Sensitivity analysis based on the eosinophil cutoff point of 300 cells/mm^3 revealed similar results for both all-cause and asthma costs, except for eosinophil count no longer being a significant predictor ($175.0; 95% CI, $12.4-$362.5; $P = .067$).

Factors indicating more severe disease (ie, more comorbidities [CCI], higher GINA step-care level, chronic OCS use, AMR 0.5 or more, and 7 or more SABA dispensed canisters) were predictors for both all-cause and asthma costs; pulmonologist visits added to all-cause costs. However, 2 or more asthma exacerbations, allergist care, elevated blood eosinophil count, non-Hispanic ethnicity, and age were predictors for asthma, but not all-cause costs. The increase in both all-cause and asthma costs associated with chronic OCS use may be attributable to the higher medical care utilization experienced in patients with chronic OCS use.[7] Consistent with our[2] and others'[3,8] findings that high blood eosinophil counts were associated with future asthma exacerbations,[2] the present analyses also found a significant increase in asthma costs associated with a blood eosinophil count of 400/mm^3 or more. Our study did not find eosinophil count a significant predictor of the all-cause costs (either at ≥400 cells/mm^3 or at ≥300 cells/mm^3). An analysis of asthma patients 12 years or older based on claims data reported a 2.2-fold increase in total annual all-cause costs associated with elevated

A

Predictors in 2010 for all-cause marginal costs in 2011 (N=2,392)	Marginal cost (2014 USD $)	95% CI		P value
Charlson comorbidity index ≥2 versus 0	4,155.90	3,101.30	5,210.50	**<0.001**
GINA 4 or 5 versus GINA 1, 2, or 3 step-care levels	1,632.80	1,124.00	2,141.60	**<0.001**
Female (Y/N)	1,262.10	664.50	1,859.80	**<0.001**
Pulmonologist visit (Y/N)	1,210.80	370.20	2,051.40	**0.005**
Oral corticosteroids ≥2.5 mg/day (Y/N)	1,155.20	358.30	1,952.10	**0.004**
Asthma Medication Ratio ≥0.5 (Y/N)	1,001.10	199.20	1,803.10	**0.014**
≥7 Short-acting β2-agonist canisters (Y/N)	726.30	1.70	1,451.00	**0.049**
Charlson comorbidity index 1 versus 0	579.70	-3.70	1,163.00	0.051
White (Y/N)	542.80	-97.30	1,182.90	0.096
Obesity (Y/N)	388.90	-169.70	947.60	0.17
Non-Hispanic (Y/N)	173.50	-519.50	866.50	0.62
Allergist visit (Y/N)	158.30	-423.30	739.80	0.59
Age, increase per each 10 years	137.00	-91.00	364.00	0.24
Less than high school educated (Y/N)	-166.70	-1,083.70	750.30	0.72
≥2 Asthma exacerbations (Y/N)	-150.70	-894.80	593.50	0.69
Blood eosinophil ≥400 versus <400 cells/mm^3	-411.70	-1,078.20	254.80	0.23
Current smoker (Y/N)	-476.00	-1,365.60	413.50	0.29



B

Predictors in 2010 for asthma-related marginal costs in 2011 (N=2,392)	Marginal costs (2014 USD $)	95% CI		P value
GINA 4 or 5 versus GINA 1, 2, or 3 step-care levels	1,225.70	1,063.10	1,388.30	**<0.001**
Asthma Medication Ratio ≥0.5 (Y/N)	869.10	614.00	1,124.20	**<0.001**
≥7 short-acting β2-agonist canisters (Y/N)	824.10	590.20	1,058.10	**<0.001**
≥2 Asthma exacerbations (Y/N)	601.50	276.40	926.60	**<0.001**
Oral corticosteroids ≥2.5 mg/day (Y/N)	420.60	103.00	738.10	**0.009**
Allergist visit (Y/N)	338.40	150.30	526.60	**<0.001**
Charlson comorbidity index ≥2 versus 0	334.20	45.10	623.20	**0.023**
Blood eosinophil ≥400 versus <400 cells/mm^3	292.60	64.50	520.80	**0.012**
Non-Hispanic (Y/N)	287.80	67.90	507.60	**0.010**
Age: increase per each 10 years	180.00	107.00	253.00	**<0.001**
Charlson comorbidity index 1 versus 0	177.30	-62.00	416.60	0.15
Female sex (Y/N)	177.00	-8.10	362.10	0.061
Pulmonologist visit (Y/N)	162.00	-139.20	463.20	0.29
Obesity (Y/N)	91.40	-84.00	266.90	0.31
White (Y/N)	82.60	-117.90	283.10	0.42
Current smoker (Y/N)	-144.20	-453.90	165.60	0.36
Less than high school education (Y/N)	-266.30	-553.50	20.90	0.07

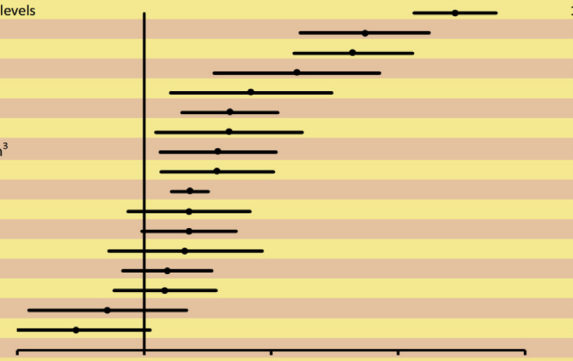


FIGURE 1. Adjusted average direct marginal cost per patient in 2011 by baseline predictor in 2010 in adults with persistent asthma. **A**, All-cause health care costs. **B**, Asthma-related health care costs. All the cost estimates were derived from generalized linear models with a gamma distribution and a log-link function.[4] The predictors in 2010 were age, sex, ethnicity, high school education, obesity, current smoking, CCI, blood eosinophil count (binary at 400 cells/mm^3 cutoff point), GINA step-care level, 2 or more asthma exacerbations, 2.5 mg/d or more OCS cumulative daily dosage (representing chronic OCS use), 7 or more SABA canisters dispensed, AMR 0.5 or more, allergist visit, and pulmonologist visit. *N*, No; *Y*, yes.

blood eosinophil counts (defined as ≥400 cells/mm^3) ($17,963 for elevated eosinophil count vs $8,268 for nonelevated eosinophil count).[9] In the same study, increasing age and CCI were also significantly associated with all-cause costs.[9] Chastek et al[10] reported unadjusted total asthma-related costs in a follow-up year of $1775 for a persistent asthma cohort and $5174 for a severe asthma cohort from a commercial or Medicare Advantage managed-care claims data set, comparable to the costs found in the present study of $2277 and $4107, respectively (Table I). Substantially greater total annual all-cause costs have been noted in other studies.[9,10] Differences in total all-cause costs between our study and others may be attributable to (1) differences in study design: (a) the present cost outcomes were captured in the *third* and outcome year after requiring patients to have at least 2 years of persistent asthma, (b) nonasthma drug costs, patient copays, and deductibles were not captured, and (c) many chronic diseases were excluded; (2) differences in disease management in integrated health care systems versus fee-for-service plans; (3) differences in sociodemographic and geographic parameters in underlying populations because the present study did not include children younger than 18 years or those older than 65 years with their inherent increased frequency of comorbidities; (4) differences in asthma severity; (5) differences in approaches of monetizing resource utilization counts, as well as charges; and (6) differences in reimbursement of services across different years in each study. We previously reported that patients with eosinophil determinations compared with those without eosinophil determinations evidenced different demographic characteristics, more comorbidities, and more burdensome asthma.[2] Therefore, the study findings apply to patients with persistent asthma who had a blood eosinophil determination and generalization to those without a blood eosinophil determination should be with caution.

In summary, the present study was the first to capture the marginal costs of important phenotypic features associated with all-cause and asthma costs in a large 2-year HEDIS-defined cohort of adults with persistent asthma. Modifiable cost drivers in patients with asthma who require more intensive attention to