Ratio of Controller to Total Asthma Medications: Determinants of the Measure

Michael S. Broder, MD; Benjamin Gutierrez, PhD; Eunice Chang, PhD; David Meddis, PhD; and Michael Schatz, MD

Objective: To investigate differences in demographics, physician specialty, and medication use between patients who achieve high versus low ratios of controller to total asthma medications.

Study Design: Cohort analysis.

Methods: We used a Health Insurance Portability and Accountability Act–compliant claims database to identify patients aged 5 to 56 years with persistent asthma during a premeasurement year and a measurement year. Based on values in the measurement year, the ratio of controller to total asthma medications ratio was defined using the following formula: (Units of Controllers) / (Units of Controllers + Relievers). Descriptive analysis and multivariate logistic regression models were used to examine patients with high and low ratios.

Results: The final study group comprised 38,538 patients with persistent asthma; 28,496 (73.9%) had high ratios. Specialty of usual-care physician differed (P <.001), with more high-ratio patients than low-ratio patients having an allergist or pulmonologist. Patients who received combination inhaled corticosteroid–long-acting β-agonist therapy (odds ratio [OR], 2.4) or leukotriene receptor antagonist therapy (OR, 3.5) were more likely to be in the high-ratio group compared with those dispensed a single inhaled corticosteroid. High-group and low-group assignment could be calculated by partial-year data: assignment based on 1 quarter of data was concordant with assignment based on full-year ratio in 91% of cases (Pearson product moment correlation coefficient, 0.864; κ statistic, 0.761), and assignment based on 2 quarters of data was concordant with full-year results in 94% of cases (Pearson product moment correlation coefficient, 0.928; κ statistic, 0.843).

Conclusions: A high ratio of controller to total asthma medications is associated with greater controller adherence and with more controller fills. The ratio can be calculated using 1 or 2 quarters of pharmacy claims data, at a time when intervention may reduce asthma-related exacerbations. Interventions that may improve the ratio include changing from single inhaled corticosteroid therapy and from asthma specialist care.

(Am J Manag Care. 2010;16(3):170-178)

For author information and disclosures, see end of text.

The Healthcare Effectiveness Data and Information Set (HEDIS), developed by the National Committee for Quality Assurance,[1] reports quality measures for various health conditions. The asthma measure assesses the proportion of patients who are prescribed a controller medication in a given year, and it has become a focus of quality improvement programs nationally.[2] The current measure may not be ideal for directing improvement efforts because patients with "appropriate" care (those with ≥1 controller medication prescribed) may actually have an increased risk of requiring emergency hospital care.[3]

A revision to the measure that would address this issue has been proposed.[4,5] This proposed measure, the ratio of controller to total (controller plus rescue) asthma medications, has been shown to be a better indicator of the need for emergency hospital care than the HEDIS measure.[5,6] A higher ratio also is significantly related to improved asthma-related quality of life, better disease control, and reduced symptoms.[5] In addition to validating its association with relevant outcomes, studies[6,7] of the ratio have demonstrated its performance among various plans and regions, tested different inclusion criteria, and examined the ideal cutoff point for high versus low ratios. However, little information is available regarding which patient populations perform well on this measure or what individual patient characteristics indicate poor performance. The type and number of controller and reliever medications that comprise the ratio have not been studied extensively. Having a better understanding of this ratio measure would improve plans' (and physicians') ability to identify patients at risk of having poorly controlled asthma and might help plans, through targeted intervention, improve their compliance with the measure.

The primary objectives of this study were to investigate differences between patients who achieve high versus low ratios of controller to total asthma medications, to identify patient characteristics that are associated with high ratios, and to compare the type and number of controller and reliever medications used by patients with high versus low ratios.

METHODS

We conducted a cohort study to examine the characteristics of patients with high and low ratios of controller to total asthma medications.

In this article
Take-Away Points / p171
www.ajmc.com
Full text and PDF
Web exclusive
eAppendix

We used the PharMetrics database, a Health Insurance Portability and Accountability Act–compliant administrative claims database (www.imshealth.com). This database contains adjudicated pharmacy and medical claims submitted by providers, healthcare facilities, and pharmacies. The study was exempt from human subjects review.

Take-Away Points

The ratio of controller to total asthma medications may be a useful tool for improving quality of care.

- Patients with greater adherence to controller therapy are more likely to have high ratios.
- Higher ratios are seen in patients treated with medications other than single inhaled corticosteroids.
- Ratios may be calculated using less than a full year of data.

Study Population

We included patients who had persistent asthma as defined by the current HEDIS measure during a premeasurement year (October 1, 2005, to September 30, 2006) and a measurement year (October 1, 2006, to September 30, 2007) who were aged 5 to 56 years during the measurement year and who were continuously enrolled during those 2 years. Patients with emphysema or chronic obstructive pulmonary disease (COPD) (*International Classification of Diseases, Ninth Revision, Clinical Modification* [*ICD-9-CM*] codes 492, 518.2, 491.2, 493.2, 496, and 506.4) were excluded.

Outcome Measure

The main outcome measure was the ratio of controller to total asthma medications, as described by Schatz et al.[5] Patients with a ratio of at least 0.5 were classified as high-ratio patients, and those with a ratio of less than 0.5 were classified as low-ratio patients. Based on values in the measurement year, the ratio was defined using the following formula: (Units of Controllers)/(Units of Controllers + Relievers). Controller medications included cromolyn sodium, leukotriene modifiers, nedocromil, inhaled corticosteroids (including combination inhaled corticosteroid–long-acting β-agonists), methylxanthines, and omalizumab. Reliever medications included inhaled short-acting β-agonists. Long-acting β-agonists as individual drugs or as part of combination therapy were not counted in the numerator or the denominator for the ratio calculation.

To count medication units for oral medications, 1 U was considered equivalent to 1 dispensing event (for a 30-day supply). If a patient received a 90-day supply, it was considered 3 U. For inhalers, 1 U was 1 canister. For injected medications, 1 U was 1 claim, but if a subsequent claim had a service date within 21 days, it was ignored (eg, claims on days 1 and 15 counted as 1 U).[5] We used HEDIS definitions to count dispensing events.[1] For injected medications (omalizumab), each claim was counted as a dispensing event.

The number of canisters dispensed in each claim was determined by a ratio of quantity to package size. For example, a claim of triamcinolone acetonide inhalation aerosol, 75 mcg/actuation (20-g package size), with a quantity of 20 was interpreted as 1 canister dispensed. Any claim with a ratio of quantity to package size of less than 1 was counted as 1 canister. For claims with a ratio of quantity to package size of at least 1, we rounded the number to a whole number of canisters. For example, claims of aerosol solution, 75 mcg/actuation (20-g package size), with quantities of 35 and 25 were counted as 2 canisters (35/20 = 1.75 [rounded to 2]) and 1 canister (25/20 = 1.25 [rounded to 1]), respectively. If a claim was for more than 12 canisters, it was truncated to 12 canisters.

Patient Characteristics

We evaluated patient characteristics in the premeasurement year and in the measurement year. Characteristics evaluated in the measurement year included demographics (age, sex, and geographic region of care), specialty of usual-care physician, and controller or reliever use. To determine the specialties of the patients' usual physicians, we reviewed office visit claims for evidence of evaluation and management services (defined as those with *Current Procedural Terminology* codes for office or other outpatient services, office consultations, and preventive medicine services). We identified the specialty of the physician with whom each patient had the most evaluation and management visits during the measurement year and considered that the patient's usual-care physician.[8] We reported extent of controller and reliever use in the measurement year and calculated controller medication possession ratios (MPRs), defined as the sum of the "days of supply" divided by the total number of days in the measurement year (365 days). If the days of supply exceeded 365, the total number of covered days was truncated to 365 days.

We assessed asthma control in the premeasurement year with variables that reflect impairment and risk using 2 key concepts described by the National Asthma Education and Prevention Program.[9] To assess impairment, we measured whether patients had 6 or more short-acting β-agonist canisters dispensed in the premeasurement year. Such use has been shown to be a marker of impairment in previous investigations.[10,11] To assess risk, we measured whether patients had the following: (1) at least 2 oral corticosteroid dispensing events, (2) any asthma-related (with primary diagnosis of asthma

Table 1. Characteristics of Patients in the Measurement Year by Ratio of Controller to Total Asthma Medications

Characteristic	Ratio <0.5 (n = 10,042)	Ratio ≥0.5 (n = 28,496)	All Patients (N = 38,538)	*P*
Age, mean (SD), y	32.0 (15.7)	32.3 (17.6)	32.2 (17.1)	.12
Age group, y, No. (%)				
5-9	877 (8.7)	4014 (14.1)	4891 (12.7)	<.001
10-17	1775 (17.7)	5243 (18.4)	7018 (18.2)	
18-56	7390 (73.6)	19,239 (67.5)	26,629 (69.1)	
Female sex, No. (%)	5071 (50.5)	15,740 (55.2)	20,811 (54.0)	<.001
Geographic region of care, No. (%)				
Northeast	1621 (16.1)	4882 (17.1)	6503 (16.9)	<.001
Midwest	6131 (61.1)	16,078 (56.4)	22,209 (57.6)	
South	1369 (13.6)	5201 (18.3)	6570 (17.0)	
West	921 (9.2)	2335 (8.2)	3256 (8.4)	
Specialty of usual-care physician, No. (%)				<.001
Allergist	388 (3.9)	2174 (7.6)	2562 (6.6)	
Pulmonologist	224 (2.2)	829 (2.9)	1053 (2.7)	
Primary care	5967 (59.4)	16,339 (57.3)	22,306 (57.9)	
Other	3463 (34.5)	9154 (32.1)	12,617 (32.7)	
Controller use				
Controller medication possession ratio, mean (SD)	0.203 (0.230)	0.603 (0.241)	0.499 (0.296)	<.001
No. of controllers, mean (SD), U	3.1 (3.9)	10.3 (6.2)	8.4 (6.5)	<.001
Quartile of controller use, No. (%)				
1, 0-3 U	6823 (67.9)	2181 (7.7)	9004 (23.4)	<.001
2, 4-7 U	2048 (20.4)	8870 (31.1)	10,918 (28.3)	
3, 8-11 U	761 (7.6)	7383 (25.9)	8144 (21.1)	
4, ≥12 U	410 (4.1)	10,062 (35.3)	10,472 (27.2)	
Reliever use				
No. of relievers, short-acting β-agonist, mean (SD), U	10.1 (7.2)	2.4 (3.0)	4.4 (5.6)	<.001
Quartile of reliever use, No. (%)				<.001
1, 0 U	0	8432 (29.6)	8432 (21.9)	
2, 1-2 U	261 (2.6)	10,603 (37.2)	10,864 (28.2)	
3, 3-6 U	3428 (34.1)	7125 (25.0)	10,553 (27.4)	
4, ≥7 U	6353 (63.3)	2336 (8.2)	8689 (22.5)	

[*ICD-9-CM* code 493]) hospitalization, or (3) any asthma-related emergency department (ED) visits.[12] We assessed impairment and risk in the premeasurement year rather than in the measurement year to understand the effect of baseline control on the ratio.

To describe patient clinical characteristics and chronic disease burden, we used claims in the premeasurement year and in the measurement year to capture more completely any relevant diagnoses. We evaluated clinical characteristics using individual and grouped diagnoses. We used Clinical Classifications Software, developed by the Agency for Healthcare Research and Quality (http://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp), to identify patients with mental disorders and disorders of the gastrointestinal system, conditions that may affect medication adherence and asthma severity.[13] Individual diagnoses included reflux (*ICD-9-CM* codes 530.11 and 530.81), sinusitis (codes 461.x and 473.x), rhinitis (codes 477.0, 477.8, 477.9, and 472.0), acute upper respiratory tract infection (code

465.x), and nasal polyposis (code 471.x). To account for the burden of chronic health conditions, we applied the method by Hwang et al[14] to assess the number of chronic health conditions each patient had.

Statistical Analysis

We conducted a descriptive analysis to compare demographic and clinical characteristics, specialty of usual-care physician, and medication use between the high-ratio and low-ratio groups. In addition to high-ratio and low-ratio groups, we further divided patients into 4 groups based on their actual ratios (<0.25, 0.25 to <0.5, 0.5 to <0.75, and ≥0.75) and compared their characteristics. We studied quartiles for a more precise evaluation. We conducted bivariate analyses comparing selected characteristics between the high-ratio and low-ratio groups. Characteristics that were significantly associated with the ratio were included in the multivariate models as independent variables. We compared ratios calculated using the first quarter, the first 2 quarters, and the first 3 quarters of data with full-year ratios using Pearson product moment correlation coefficient and κ statistic.

We used 2 multivariate logistic regression models to estimate the association between certain characteristics and a high ratio. The first model excluded patients with a zero ratio (no controller use). It also excluded patients treated with only theophylline or cromolyn sodium, as these drugs are not commonly used as single agents in current practice (<1% of patients in the study). The second model included patients with no controller use. We reported adjusted odds ratios (ORs) and their 95% confidence intervals (CIs). All tests were 2-sided with a significance level of .05. All data transformations and statistical analyses were performed using SAS version 9.1 (SAS Institute, Inc, Cary, NC).

RESULTS

We identified 150,903 patients with persistent asthma in the premeasurement year and 156,649 in the measurement year. After excluding those who did not meet the age criteria, those who were not continuously enrolled, those who had evidence of emphysema or COPD, and those who did not use controllers or relievers in the measurement year, 38,538 patients remained (**eAppendix** available at **www.ajmc.com**).

Of the final study cohort, 28,496 (73.9%) were classified as having high (≥0.5) ratios. The mean age did not differ between the groups with high versus low ratios. Age group, sex, and geographic region of care differed (P <.001), with a higher proportion of high-ratio patients aged 5 to 9 years (14.1% vs 8.7%), female (55.2% vs 50.5%), and from the South (18.3% vs 13.6%). Specialty of usual-care physician in the measurement year differed (P <.001), with a higher proportion of high-ratio than low-ratio patients having an allergist (7.6% vs 3.9%) or a pulmonologist (2.9% vs 2.2%) (**Table 1**).

The mean MPR in the measurement year was 0.603 for high-ratio patients and 0.203 for low-ratio patients (Table 1). High-ratio patients used a mean of 10.3 U of controllers; low-ratio patients used a mean of 3.1 U (P <.001). Controller medication use differed between groups (P <.001): 7.7% of high-ratio patients used 0 to 3 U (lowest quartile) compared with 67.9% of low-ratio patients, and 35.3% of high-ratio patients used at least 12 U (highest quartile) compared with 4.1% of low-ratio patients. There were significant differences in reliever use during the measurement year (P <.001): the mean number of reliever units used was 2.4 in the high-ratio group compared with 10.1 in the low-ratio group. Almost 30% of high-ratio patients had no reliever fills in the measurement year (0% of low-ratio patients had no reliever fills, as by definition having no reliever use produces a ratio of 1.0). The highest quartile of reliever use included those with 7 or more canisters used. Just over 8% of high-ratio patients and 63.3% of low-ratio patients were in this group.

There was a statistically significant difference between the groups in asthma control measures during the premeasurement year. High-ratio patients had less impairment, with only 16.4% filling 6 or more short-acting β-agonist canisters compared with 63.3% of low-ratio patients (P <.001) (**Table 2**). High-ratio patients had lower risk than low-ratio patients in each of the areas measured (P <.001 for each category). High-ratio patients had more total chronic health conditions (4.0 vs 3.6, P <.001) and more of the individual comorbidities assessed, except for mental disorders, which were more common among low-ratio patients (**Table 3**). When we further classified patients into 4 ratio groups (<0.25, 0.25 to <0.5, 0.5 to <0.75, and ≥0.75), the results for medication use, asthma control, and comorbidities were similar (data not shown).

High-group and low-group assignment could be calculated using partial-year data. High-ratio vs low-ratio group assignment based on 1 quarter of data was concordant with group assignment based on full-year ratio in 91% of cases. Adding a second quarter of data increased concordance to 94%. Pearson product moment correlation coefficient of partial-year to full-year ratio (using a continuous [0-1.0] variable for the ratio) was 0.864 for 1 quarter and 0.928 for 2 quarters. κ statistic, calculated using the categories of high ratio and low ratio, was 0.761 for 1 quarter and 0.843 for 2 quarters (**Table 4**).

The 2 multivariate models produced similar results. The model that excluded patients without controller use allowed us to estimate the effect of specific patterns of medication use on the ratio. In multivariate analysis of controller users, older

Table 2. Asthma Control in the Premeasurement Year by Ratio of Controller to Total Asthma Medications

Variable	No. (%)			
	Ratio			
	<0.5 (n = 10,042)	≥0.5 (n = 28,496)	All Patients (N = 38,538)	*P*
Impairment				
Filled ≥6 short-acting β-agonist canisters	6356 (63.3)	4684 (16.4)	11,040 (28.6)	<.001
Risk				
Any asthma-related hospitalization	273 (2.7)	393 (1.4)	666 (1.7)	<.001
Any asthma-related emergency department visit	1019 (10.1)	1246 (4.4)	2265 (5.9)	<.001
Filled ≥2 oral corticosteroid prescriptions	1755 (17.5)	4383 (15.4)	6138 (15.9)	<.001

age and male sex significantly lowered the odds of being in the high-ratio group, with an OR of 0.54 (95% CI, 0.48-0.61) among patients aged 10 to 17 years compared with patients aged 5 to 9 years and an OR of 0.69 (95% CI, 0.61-0.77) among patients aged 18 to 56 years compared with patients aged 5 to 9 years. Geographic region of care was associated with ratio group, with an OR of 1.14 (95% CI, 1.01-1.30) for the Northeast compared with the West and an OR of 1.18 (95% CI, 1.03-1.34) for the South compared with the West. Compared with patients having primary care physicians (internists and family physicians), patients having allergists as usual-care physicians had an OR of 1.35 (95% CI, 1.17-1.55) for being in the high-ratio group, and patients having pulmonologists had an OR of 1.26 (95% CI, 1.04-1.52) (Table 5).

There was a statistically significant association between the type of controller used in the measurement year and the ratio group. Patients whose only controller was a combination inhaled corticosteroid–long-acting β-agonist product had 2.36 (95% CI, 2.15-2.58) times the odds of being in the high-ratio group compared with patients who used only single inhaled corticosteroids (Table 5). Similarly, patients with a leukotriene receptor antagonist as their only controller had an OR of 3.49 (95% CI, 3.15-3.87) for being in the high-ratio group compared with patients who used a single inhaled corticosteroid controller. Users of multiple controllers had an OR of 7.45 (95% CI, 6.80-8.17) for being in the high-ratio group.

Asthma control was associated with outcomes. Patients who filled 6 or more short-acting β-agonist canisters in the premeasurement year, a measure of impairment, had significantly lower odds (OR, 0.11; 95% CI, 0.10-0.12) of having high ratios than patients who filled fewer than 6 canisters (Table 5). Having any asthma-related hospitalization, any asthma-related ED visit, or having filled at least 2 oral corticosteroid prescriptions in the premeasurement year were all significantly associated with lower odds of having a high

Table 3. Select Comorbidities in the Premeasurement and Measurement Years by Ratio of Controller to Total Asthma Medications

Variable	Ratio			
	<0.5 (n = 10,042)	≥0.5 (n = 28,496)	All Patients (N = 38,538)	*P*
Mental disorder, No. (%)	3412 (34.0)	8129 (28.5)	11,541 (29.9)	<.001
Disease in digestive system, No. (%)	3501 (34.9)	10,898 (38.2)	14,399 (37.4)	<.001
Reflux, No. (%)	1306 (13.0)	4486 (15.7)	5792 (15.0)	<.001
Sinusitis, No. (%)	3345 (33.3)	11,486 (40.3)	14,831 (38.5)	<.001
Rhinitis, No. (%)	3706 (36.9)	15,157 (53.2)	18,863 (48.9)	<.001
Acute upper respiratory tract infection, No. (%)	2749 (27.4)	8240 (28.9)	10,989 (28.5)	<.001
Nasal polyposis, No. (%)	153 (1.5)	606 (2.1)	759 (2.0)	.003
No. of chronic health conditions				
Mean (SD)	3.6 (2.8)	4.0 (3.0)	3.9 (2.9)	<.001
Median (interquartile range)	2 (1-3)	2 (1-4)	2 (1-4)	—

Table 4. Ratios of Controller to Total Asthma Medications Using Partial-Year Data

Variable	Ratio in the Measurement Year, No. (%)		Concordant Patients, %[a]	Pearson Product Moment Correlation Coefficient[b]	κ Statistic
	High	Low			
Ratio in the First Quarter (n = 34,887)[c]					
High	24,505 (70.2)	1668 (4.8)	90.9	0.864	0.761
Low	1485 (4.3)	7229 (20.7)			
Ratio in the First 2 Quarters (n = 37,688)[c]					
High	26,848 (71.2)	1167 (3.1)	94.0	0.928	0.843
Low	1098 (2.9)	8575 (22.8)			

[a]Patients were classified in the same ratio group using full-year or partial-year data.
[b]Continuous variables of ratios were used to determine Pearson product moment correlation coefficient.
[c]There were 3651 patients with an undefined ratio in the first quarter and 850 patients with an undefined ratio in the first 2 quarters.

ratio. Patients with a mental disorder had lower odds of being in the high-ratio group (OR, 0.75; 95% CI, 0.70-0.81), whereas patients with rhinitis had higher odds (OR, 1.22; 95% CI, 1.14-1.31). Each additional chronic health condition increased the odds of being in the high-ratio group (OR, 1.04; 95% CI, 1.02-1.05).

DISCUSSION

Limitations and problems with the current HEDIS asthma measure have led to consideration of some modifications. One potential modification is the use of a ratio of controller to total asthma medications as the primary quality measure. Using a ratio that is associated with outcomes may result in improvements in the quality of asthma care, and the measure identifies a subpopulation that may benefit from attempts at improvements in care. In a study[7] using 3 separate databases, a high ratio was consistently associated with improved outcomes. The proportion of patients with a ratio of at least 0.5 varied from 70% to 75% across the 3 databases. High ratios are also associated with improved patient-reported outcomes,[5] but little has been published about specific differences between high-ratio and low-ratio patients or about the stability of the measure over time.

In the present study, 73.9% of patients had high ratios, similar to other published studies[6,7]; the mean age and the slight female preponderance were also similar to prior work. In an unadjusted analysis, children younger than 10 years, female patients, and those with allergists and pulmonologists as their usual-care physician were more likely to have high ratios, and these results persisted after adjustment for baseline characteristics. Other variables that had a statistically significant association with the high-ratio group in the multivariate analyses included lack of markers of impairment or risk, use of controllers other than single inhaled corticosteroids, absence of mental disorders, presence of rhinitis or acute upper respiratory tract infection diagnosis, and more chronic health conditions.

In multivariate analyses, the strongest variable associated with ratio group was the type of controller therapy, with single inhaled corticosteroids being associated with lower ratios than combination inhaled corticosteroid–long-acting β-agonist, leukotriene receptor antagonist, and multiple controllers. Patients are more adherent with combination inhaled corticosteroid–long-acting β-agonist inhalers than with concurrent treatment using separate inhaled corticosteroid and long-acting β-agonist inhalers.[15] In addition, combination therapy is generally more effective than similar doses of inhaled corticosteroid monotherapy in relieving symptoms and improving lung function,[16] so patients might be more consistent in their use of these therapies. Patients receiving long-acting β-agonist therapy may use less short-acting β-agonist, which may increase the ratio for combination products compared with single inhaled corticosteroid. However, if the reduced use of short-acting β-agonist reflects decreased symptoms, this is not an artificial increase. Adherence to leukotriene receptor antagonist therapy is also greater than adherence to inhaled corticosteroid monotherapy.[17] Patients treated with multiple controllers were many times more likely to have high ratios, possibly as a result of the calculation used to determine the ratio. To be categorized as using multiple controllers, a patient needed at least 2 controller fills (eg, to identify ≥2 types of controllers), whereas some users of single therapies had only 1 fill, and a greater number of controller fills results in a higher ratio.

Ratios also increase with increasing controller adherence. This relationship between greater adherence as measured by the MPR and higher ratios may explain some of the associa-

Table 5. Multivariate Analysis Odds Ratios for High Versus Low Ratios of Controller to Total Asthma Medication

Variable	Controller Users[a] (n = 35,043) OR (95% CI)	*P*	All Patients (N = 38,538) OR (95% CI)	*P*
Measurement Year				
Age group, y				
10-17 vs 5-9	0.54 (0.48-0.61)	<.001	0.58 (0.53-0.65)	<.001
18-56 vs 5-9	0.69 (0.61-0.77)	<.001	0.53 (0.49-0.59)	<.001
Sex				
Female vs male	1.11 (1.04-1.18)	.002	1.17 (1.11-1.23)	<.001
Geographic region of care				
Midwest vs West	1.07 (0.96-1.20)	.22	1.11 (1.01-1.22)	.03
Northeast vs West	1.14 (1.01-1.30)	.04	1.12 (1.00-1.24)	.049
South vs West	1.18 (1.03-1.34)	.02	1.20 (1.08-1.34)	.001
Specialty of usual-care physician				
Allergist vs primary care	1.35 (1.17-1.55)	<.001	1.52 (1.34-1.73)	<.001
Pulmonologist vs primary care	1.26 (1.04-1.52)	.02	1.57 (1.33-1.86)	<.001
Other vs primary care	1.13 (1.06-1.22)	<.001	0.97 (0.91-1.03)	.29
Controller use				
Single combination inhaled corticosteroid–long-acting β-agonist controller vs single inhaled corticosteroid controller[b]	2.36 (2.15-2.58)	<.001	NA	NA
Single leukotriene receptor antagonist controller vs single inhaled corticosteroid controller	3.49 (3.15-3.87)	<.001	NA	NA
Multiple controllers vs single inhaled corticosteroid controller[c]	7.45 (6.80-8.17)	<.001	NA	NA
Premeasurement Year				
Impairment				
Filled ≥6 short-acting β-agonist canisters	0.11 (0.10-0.12)	<.001	0.12 (0.11-0.12)	<.001
Risk				
Any asthma-related hospitalization	0.72 (0.59-0.89)	.003	0.71 (0.59-0.86)	<.001
Any asthma-related emergency department visit	0.43 (0.38-0.48)	<.001	0.37 (0.34-0.41)	<.001
Filled ≥2 oral corticosteroid prescriptions	0.89 (0.82-0.98)	.01	1.11 (1.03-1.20)	.006
Premeasurement Year or Measurement Year				
Mental disorder	0.75 (0.70-0.81)	<.001	0.70 (0.66-0.75)	<.001
Disease in digestive system	1.06 (0.98-1.14)	.17	1.05 (0.99-1.13)	.12
Reflux	1.06 (0.96-1.18)	.26	1.12 (1.03-1.23)	.01
Sinusitis	0.99 (0.92-1.06)	.71	1.08 (1.02-1.15)	.007
Rhinitis	1.22 (1.14-1.31)	<.001	1.52 (1.44-1.61)	<.001
Acute upper respiratory tract infection	0.88 (0.82-0.94)	<.001	0.92 (0.86-0.97)	.005
Nasal polyposis	0.96 (0.77-1.21)	.75	1.16 (0.94-1.42)	.16
No. of chronic health conditions	1.04 (1.02-1.05)	<.001	1.06 (1.05-1.07)	<.001

CI indicates confidence interval; NA, not applicable; OR, odds ratio.
[a]Patients who filled at least 1 controller in the measurement year. C statistic for controller users was 0.821; C statistic for all patients was 0.787.
[b]Combination inhaled corticosteroid–long-acting β-agonist in a single inhaler.
[c]Excludes combination inhaled corticosteroid–long-acting β-agonist.

tions we observed. Higher ratios were seen in patients who had allergists or pulmonologists as their usual-care physician. Provider knowledge and communication skills influence adherence to treatment, and specialist providers may be better at communicating complex regimens to their patients with asthma.[18] Women had higher ratios, and some evidence suggests they may have better adherence than men.[19] The presence of a mental disorder was associated with a lower ratio, and some mental disorders, including depression, decrease adherence to therapy.[20] Many other factors associated with poor adherence were not captured in our study, such as patients' education, socioeconomic status, disease understanding, and belief in treatment efficacy.[18,19,21]

Some variables may mediate their effect on ratio group through their association with asthma control. Increasing numbers of chronic health conditions, as well as rhinitis and upper respiratory tract infections, all may identify patients with greater risk. These factors may also lead to more office visits and greater opportunities for prescribing controller medications. We used utilization-based measures to adjust our results for disease severity, but there were no clinical measures of severity in our database. This was a limitation of our analysis.

The goal of quality measures and tools for targeted interventions is to improve patient outcomes. Quality measures are provider oriented and aim to improve patient outcomes by improving provider adherence to treatment guidelines (eg, controllers for asthma). This is done by using quality measures as incentives for approaches such as public reporting and pay for performance. In contrast, population management (tools for targeted interventions) is patient oriented and aims to identify high-risk patients who need targeted interventions to improve outcomes. The ratio, which may be calculated from partial-year data, can be used as a quality measure or tool for population management to improve asthma outcomes. A plan interested in intervening for patients with low ratios could use data from 2 quarters or even 1 quarter to identify patients at risk for having a low ratio (if the quantities dispensed are in the 30-day to 60-day range). Interventions such as education, outreach, or medication counseling put in place after a partial-year calculation of the ratio might not only increase the ratio but also (given the demonstrated link between the ratio and outcomes) reduce emergency hospital care. We found that patients who used combination inhalers versus single inhaled corticosteroid controllers and leukotriene receptor antagonist versus single inhaled corticosteroid were more likely to have high ratios. Using this information, interventions to improve patients' ratios could be developed. For example, patients with poor control who are receiving single inhaled corticosteroids could switch to combination inhalers, and patients with poor adherence to single inhaled corticosteroids could switch to leukotriene receptor antagonists.[22] Patients who received specialty care were more likely to have high ratios; therefore, it may be beneficial to refer patients with evidence of prior impairment or risk to asthma specialists. Studies to evaluate the effectiveness of these interventions should be considered.

CONCLUSIONS

The ratio of controller to total asthma medications may be useful as a measure of the quality of asthma care. The measure can be easily calculated using existing administrative data, and patients with higher ratios have improved asthma outcomes. Higher ratios are seen among patients with greater adherence to therapy and among patients treated with medications other than single inhaled corticosteroids. Ratios are stable; interventions focused on patients with low ratios based on 1 or 2 quarters of data may reduce asthma-related exacerbations. The ratio of controller to total asthma medications may be useful as a quality measure and as a tool for targeted intervention to improve asthma outcomes.

Author Affiliations: From the Partnership for Health Analytic Research (MSB, EC); Beverly Hills, CA; AstraZeneca, LP (BG, DM), Wilmington, DE; and Kaiser Permanente Medical Center (MS), San Diego, CA.

Funding Source: This study was funded by AstraZeneca, LP.

Author Disclosures: Drs Broder and Chang report receiving payment from AstraZeneca, LP for their involvement in conducting the study and preparing the manuscript. Drs Gutierrez and Meddis are employees of AstraZeneca, LP, the company that provided funding for the study. Dr Schatz reports receiving investigator-initiated grants from Aerocrine, Genentech, GlaxoSmithKline, and Merck.

Authorship Information: Concept and design (MSB, BG, EC, DM, MS); acquisition of data (BG); analysis and interpretation of data (MSB, BG, EC, MS); drafting of the manuscript (MSB, BG, DM); critical revision of the manuscript for important intellectual content (MSB, BG, DM, MS); statistical analysis (EC); and obtaining funding (DM).

Address correspondence to: David Meddis, PhD, AstraZeneca, LP, 1800 Concord Pike, Wilmington, DE 19850. E-mail: david.meddis@astrazeneca.com.

REFERENCES

1. National Committee for Quality Assurance. *HEDIS 2008: Healthcare Effectiveness Data and Information Set.* Vol 2, Technical Specifications. Washington, DC: National Committee for Quality Assurance (NCQA); 2007:126-128.

2. Gelfand EW, Colice GL, Fromer L, Bunn WB III, Davies TJ. Use of the Health Plan Employer Data and Information Set for measuring and improving the quality of asthma care. *Ann Allergy Asthma Immunol.* 2006;97(3):298-305.

3. Berger WE, Legorreta AP, Blaiss MS, et al. The utility of the Health Plan Employer Data and Information Set (HEDIS) asthma measure to predict asthma-related outcomes. *Ann Allergy Asthma Immunol.* 2004;93(6):538-545.

4. Fuhlbrigge A, Carey VJ, Adams RJ, et al. Evaluation of asthma prescription measures and health system performance based on emergency department utilization. *Med Care.* 2004;42(5):465-471.

5. Schatz M, Zeiger RS, Vollmer WM, et al. The controller-to-total asthma medication ratio is associated with patient-centered as well as utilization outcomes. *Chest.* 2006;130(1):43-50.

6. Schatz M, Nakahiro R, Crawford W, Mendoza G, Mosen D, Stibolt TB. Asthma quality-of-care markers using administrative data. *Chest.* 2005;128(4):1968-1973.

7. Schatz M, Stempel D; American College of Allergy, Asthma and Immunology Task Force; American Academy of Allergy, Asthma and Immunology Task Force. Asthma quality-of-care measures using administrative data: relationships to subsequent exacerbations in multiple databases. *Ann Allergy Asthma Immunol.* 2008;101(3):235-239.

8. O'Malley AS, Pham HH, Schrag D, Wu B, Bach PB. Potentially avoidable hospitalizations for COPD and pneumonia: the role of physician and practice characteristics. *Med Care.* 2007;45(6):562-570.

9. National Heart, Lung, and Blood Institute, National Institutes of Health, US Department of Health and Human Services. Expert Panel Report 3 (EPR3): guidelines for the diagnosis and management of asthma. Revised August 28, 2007. http://www.nhlbi.nih.gov/guidelines/asthma/asthgdln.htm. Accessed February 17, 2009.

10. Schatz M, Zeiger RS, Vollmer WM, et al. Validation of a β-agonist long-term asthma control scale derived from computerized pharmacy data. *J Allergy Clin Immunol.* 2006;117(5):995-1000.

11. 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.

12. Schatz M, Nakahiro R, Jones CH, Roth RM, Joshua A, Petitti D. Asthma population management: development and validation of a practical 3-level risk stratification scheme. *Am J Manag Care.* 2004;10(1):25-32.

13. Cowen ME, Dusseau DJ, Toth BG, Guisinger C, Zodet MW, Shyr Y. Casemix adjustment of managed care claims data using the clinical classification for health policy research method. *Med Care.* 1998;36(7):1108-1113.

14. Hwang W, Weller W, Ireys H, Anderson G. Out-of-pocket medical spending for care of chronic conditions. *Health Aff (Millwood).* 2001;20(6):267-278.

15. Marceau C, Lemière C, Berbiche D, Perreault S, Blais L. Persistence, adherence, and effectiveness of combination therapy among adult patients with asthma. *J Allergy Clin Immunol.* 2006;118(3):574-581.

16. Greenstone IR, Ni Chroinin MN, Masse V, et al. Combination of inhaled long-acting β_2-agonists and inhaled steroids versus higher dose of inhaled steroids in children and adults with persistent asthma. *Cochrane Database Syst Rev.* 2005;4:CD005533.

17. Jones C, Santanello NC, Boccuzzi SJ, Wogen J, Strub P, Nelsen LM. Adherence to prescribed treatment for asthma: evidence from pharmacy benefits data. *J Asthma.* 2003;40(1):93-101.

18. World Health Organization. *Adherence to Long-Term Therapies: Evidence for Action.* Geneva, Switzerland: World Health Organization; 2003.

19. DiMatteo MR. Variations in patients' adherence to medical recommendations: a quantitative review of 50 years of research. *Med Care.* 2004;42(3):200-209.

20. DiMatteo MR, Lepper HS, Croghan TW. Depression is a risk factor for noncompliance with medical treatment: meta-analysis of the effects of anxiety and depression on patient compliance. *Arch Intern Med.* 2000;160(14):2101-2107.

21. Osterberg L, Blaschke T. Adherence to medication. *N Engl J Med.* 2005;353(5):487-497.

22. Tan H, Sarawate C, Singer J, et al. Impact of asthma controller medications on clinical, economic, and patient-reported outcomes. *Mayo Clin Proc.* 2009;84(8):675-684. ■