

Original Article

Clinical and Economic Outcomes in Patients with Persistent Asthma Who Attain Healthcare Effectiveness and Data Information Set Measures

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What is already known about this topic? Attainment of the asthma medication ratio (AMR) is associated with improved clinical outcomes and reduced costs, but few studies have evaluated the outcomes for patients attaining the medication management for people with asthma (MMA) measure.

What does this article add to our knowledge? MMA and/or AMR attainment was associated with significantly improved clinical outcomes. Although both MMA and AMR attainment were associated with lower exacerbation costs, only AMR attainment was associated with lower overall asthma-related costs.

How does this study impact current management guidelines? This real-world study highlights the importance of monitoring adherence to treatment and rescue inhaler use in patients with persistent asthma. Close monitoring is likely to improve adherence and, therefore, improve clinical outcomes and reduce costs.

BACKGROUND: Attainment of asthma-specific US Healthcare Effectiveness Data and Information Set (HEDIS) quality measures may be associated with improved clinical outcomes and reduced economic burden.

OBJECTIVE: We examined the relationship between the attainment of HEDIS measures asthma medication ratio (AMR) and medication management for people with asthma (MMA) on clinical and economic outcomes.

METHODS: This retrospective claims database analysis linked to ambulatory electronic medical records enrolled US patients aged ≥ 5 years with persistent asthma between May 2015 and April 2017. The attainment of AMR ≥ 0.5 and MMA $\geq 75\%$ was determined over a 1-year premeasurement period. Asthma exacerbations and asthma-related health care costs were evaluated during the subsequent 12-month measurement period, comparing patients attaining 1 or both measures with those not attaining either.

RESULTS: In total, 32,748 patients were included, 75.2% of whom attained AMR ($n = 24,388$) and/or MMA ($n = 12,042$) during the premeasurement period. Fewer attainers of 1 or more HEDIS measures had ≥ 1 asthma-related hospitalizations, emergency department visit, corticosteroid burst, or exacerbation (4.9% vs 7.3%; 9.6% vs 18.2%; 43.8% vs 51.6%; 14.3% vs 23.3%, respectively; all $P < .001$) compared with nonattainers. In adjusted analyses, HEDIS attainment was associated with a lower likelihood of exacerbations (odds ratio: 0.63, [95% confidence interval: 0.60-0.67]; $P < .001$). The attainment of ≥ 1 HEDIS measures lowered total and asthma-related costs, and asthma exacerbation-related health care costs per patient relative to nonattainers (cost ratio: 0.87, $P < .001$; 0.96, $P = .02$; and 0.59, $P < .001$, respectively). Overall and asthma-specific costs were lower for patients attaining AMR, but not MMA. **CONCLUSIONS:** HEDIS attainment was associated with significantly improved asthma outcomes and lower asthma-specific costs. © 2020 The Authors. Published by

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Abbreviations used

AMR- Asthma medication ratio
CCI- Charlson Comorbidity Index
CI- Confidence interval
ED- Emergency department
EMR- Electronic medical records
HEDIS- Healthcare Effectiveness and Data Information Set
HRU- Health care resource utilization
ICD-9-CM- The International Classification of Diseases, Ninth Revision, Clinical Modification
ICD-10-CM- The International Classification of Diseases, Tenth Revision, Clinical Modification
ICS- Inhaled corticosteroid
LABA- Long-acting β -agonist
MMA- Medication management for people with asthma
OR- Odds ratio
PCP- Primary care physician
PDC- Percentage of days covered
SABA- Short-acting β -agonist
SCS- Systemic corticosteroid
SD- Standard deviation
US- United States

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Up to half of the estimated 25 million people in the United States (US) with asthma have poor disease control despite the widespread availability of effective controller medications.¹⁻³ A significant component of this suboptimal asthma control is related to inadequate adherence to controller therapy.^{4,5}

Persistent asthma is associated with substantial clinical and economic burden. One study reported a 4.6-fold increased risk of hospitalizations and a 1.8-fold higher rate of emergency department (ED) visits for people with persistent asthma compared with those without asthma.⁶ In addition to high utilization of medical services, people with asthma have significantly lower productivity, are more likely to be unemployed, have more work absences, and have greater activity limitations than those without asthma.⁷ The total costs of inadequate asthma control, including both direct medical costs and indirect costs such as lost work days, are estimated at over \$50 billion per year⁸⁻¹⁰ and are particularly high in those with severe and persistent asthma.¹¹⁻¹⁵ Moreover, the treatment of acute exacerbations accounts for 35% to 50% of all medical expenditure, with approximately 80% of asthma-related costs incurred by patients who experience frequent exacerbations.¹⁶⁻¹⁸ Reducing asthma exacerbations and improving disease control can ease this burden.

Quality measures are tools used to measure the outcomes and value of health care provided, often in comparison with specific target performance goals. The primary organization that accredits programs and health care organizations on performance is The National Committee for Quality Assurance. A variety of metrics are used for assessment, and one of the primary measures

is the Healthcare Effectiveness Data and Information Set (HEDIS), which is a standardized set of measures adopted by most health plans. HEDIS measures involve 6 domains of care: effectiveness of care, access/availability of care, experience of care, utilization and relative resource use, health plan descriptive information, and measures collected using electronic clinical data systems.¹⁹

Two of the current HEDIS asthma-specific measures are designed to assess the use of controller medication in asthma, which is known to be important to the guideline-based treatment of persistent asthma. These measures are the asthma medication ratio (AMR), which quantifies the ratio of controller to rescue plus controller dispensing, and the medication management for people with asthma (MMA), which quantifies patients' adherence over time to asthma controller medication. Although published evidence suggests that adherence to an AMR threshold ≥ 0.50 is associated with improvements in clinical asthma outcomes (including hospitalizations, emergency hospital care, and symptom control) for both children and adults,²⁰⁻²² MMA has shown less correlation with positive clinical outcomes than AMR.²³

The aim of this retrospective database study was to evaluate clinical and economic outcomes of patients with persistent asthma, stratified according to the attainment of HEDIS measures (AMR and/or MMA). Furthermore, this study investigated the patient characteristics associated with the attainment of each of these 2 measures.

METHODS

Study database

This retrospective cohort study leveraged IQVIA's Real-World Data Adjudicated Claims US (formerly known as PharMetrics Plus) database linked to ambulatory electronic medical records (EMR), with data from May 1, 2015, to April 30, 2017.²⁴ The database comprises adjudicated claims for more than 150 million unique patients across the US, with approximately 40 million active patients. Records in the database are representative of the national, commercially insured population regarding age and sex. Patients, grouped by the first 3 digits of their ZIP code, from every metropolitan statistical area of the US are included in the database, which contains data covering 90% of US hospitals, 80% of US doctors, and 85% of Fortune 100 companies.

Key elements of the database include demographic characteristics, health plan type, payer type, pharmacy and medical benefit, and the start and stop dates of health plan enrolment. The database contains detailed information on inpatient and outpatient diagnoses and procedures, inpatient admissions and discharges, provider specialty and identification, and retail and mail-order prescription records. All claims have dates of service, amounts billed by providers, and amounts allowed and paid by the health plan.

The IQVIA Ambulatory EMR data asset comprises over 60 million patient records sourced from "opt-in" provider research networks. The aggregated database comprises records collected by over 70,000 physicians from practices and physician networks across the US. Approximately half of the contributing physicians are primary care practitioners, the remainder being specialists. Key data elements of the EMR files include patient demographics, vitals (eg, weight and body mass index), clinical history, laboratory tests, medication use, and patients' visits to their health care professional. All data were Health Insurance Portability and Accountability Act compliant to protect patient privacy.

Study population

The study population included patients aged ≥ 5 years, with evidence of persistent asthma per HEDIS criteria,^{22,23,25,26} who were enrolled in a health care plan continuously over a 12-month premeasurement (baseline) period (May 1, 2015, to April 30, 2016) and a subsequent 12-month measurement period (May 1, 2016, to April 30, 2017). Persistent asthma is defined as at least one of the following criteria being met: at least 1 ED visit or hospitalization with asthma as the principal diagnosis (The International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM]: 493.xx, ICD-10-CM: J45.xx), at least 4 outpatient asthma visits with asthma as one of the listed diagnoses, plus at least 2 asthma medication dispensing events (including reliever, controller, and systemic corticosteroids), and/or at least 4 asthma medication dispensing events in a 12-month period.^{22,23,25,26} Patients were required to meet at least one of the above-listed criteria in each of 2 successive years (the premeasurement year and the measurement year). Exclusion criteria included prior diagnosis of any respiratory tract cancer, chronic obstructive pulmonary disease, or cystic fibrosis during the premeasurement period, incomplete data, and other data quality issues (eg, outlier data).

Satisfactory quality of care during the premeasurement period was defined according to HEDIS as an AMR ≥ 0.5 and/or an MMA $\geq 75\%$. An AMR of ≥ 0.50 was determined as the ratio of the number of units of controller medication to the total number of units of asthma medication (controller plus relievers) dispensed during the premeasurement period. MMA was determined by the percentage of days covered (PDC), which is the proportion of days covered by at least 1 asthma controller medication in the time period between the index date of the dispensing event and the last day of the premeasurement period. Criteria for MMA attainment ($\geq 75\%$) were met if the PDC was $\geq 75\%$ regardless of the type or number of controller medications used in combination. When calculating MMA, patients with 1 prescription for 30 days of supply were considered on therapy for 30 days.^{22,25}

Patients meeting the inclusion criteria were classified into 2 mutually exclusive cohorts based on HEDIS attainment of at least 1 measure (AMR ≥ 0.50 and/or MMA $\geq 75\%$) in the premeasurement period. Patients were also grouped by AMR (≥ 0.50 ; < 0.50) and MMA ($\geq 75\%$; $< 75\%$) attainment individually.

Outcomes during the measurement period

Outcomes were evaluated during the measurement year and for patients grouped according to HEDIS attainment during the premeasurement period. Evaluated asthma clinical outcomes included systemic corticosteroid (SCS) burst (defined as a prescription for ≥ 3 days and < 14 days), asthma exacerbations (defined as any claim for ICD-9-CM codes 493.02, 493.12, 493.22, 493.92, or ICD-10-CM codes J45.21, J44.1, J45.901), and asthma-related hospitalizations and ED visits. Data on inpatient, outpatient, and ED visits, and prescription medication costs were used to calculate total health care costs, asthma-related health care costs (claims with asthma as a diagnosis and/or prescription for asthma medication), and asthma exacerbation-related health care costs. In this study, costs were the sum of allowed payment amounts for services, including the amount paid by the patients' insurance company plus the amount paid by the patient.

Statistical analyses

Patient demographics, clinical characteristics, medication use (full list available in Table E2, available in this article's Online Repository

at www.jaci-inpractice.org), and study outcomes were reported by the cohort for the premeasurement period. Missing data were not imputed. *P* values comparing study measures across cohorts were calculated using the χ^2 test for categorical variables and the Wilcoxon rank-sum test or *t*-test for continuous variables, depending on the distribution of data. Statistical tests were 2-sided, with an alpha level of 0.05 for statistical significance. All analyses were conducted using SAS version 9.4 (SAS Institute Inc., Cary, NC). Multivariate regression models were developed to examine associations between the attainment of at least 1 HEDIS measure and the likelihood of asthma exacerbation, total asthma-related health care costs, and exacerbation-related health care costs after adjusting for demographics, clinical characteristics, and health resource utilization (HRU). Logistic regression was used to model the likelihood of an asthma exacerbation. Generalized linear models with gamma distribution and log link function were used to model costs. All models included the same covariates and included HEDIS measure attainment during the premeasurement period, age, sex, race, region, health plan type (preferred provider organization vs health maintenance organization), payer type (Medicaid/Medicare vs commercial), visit to an asthma specialist during baseline, Charlson Comorbidity Index (CCI), smoking status, and relevant comorbidities during the premeasurement period (anemia, depression, hypertension, obstructive sleep apnea, rheumatoid arthritis, allergic rhinitis, chronic sinusitis, gastroesophageal reflux disease, eczema/atopic dermatitis). Analyses were repeated to test associations with the attainment of AMR and MMA, individually. Effect modification was not assessed because of the lack of evidence suggesting effect modification.

RESULTS

A total of 32,748 eligible patients were included in this study (Figure 1). In the premeasurement period, most patients (74.5%, $n = 24,388$) attained a satisfactory level for AMR, whereas only one-third of patients (36.8%, $n = 12,042$) attained a satisfactory level for MMA. Nearly all patients (97.6%, $n = 11,784$) who attained satisfactory levels for MMA also attained AMR targets. Overall, 75.2% ($n = 24,646$) of patients attained at least 1 HEDIS measure (AMR and/or MMA) and 24.8% ($n = 8102$) of patients did not attain either HEDIS measure.

Patient demographics and clinical characteristics

Patient demographics and clinical characteristics are summarized in Table 1 and Table E1 (available in this article's Online Repository at www.jaci-inpractice.org). Patients who attained at least 1 HEDIS measure were more likely to be white, female, belong to a preferred provider organization health plan, and have commercial insurance than nonattainers (Table 1).

AMR attainers were slightly older (mean $\pm$ standard deviation [SD] age: 41.4 ± 18.7 years) than nonattainers (40.2 ± 17.0 years), and more children (aged 5-14 years) achieved the target AMR (15.1%, $n = 3693$) than those who did not (11.1%, $n = 929$). Similarly, MMA attainers, regardless of AMR attainment, were older than nonattainers (mean $\pm$ SD: 44.6 ± 17.8 vs 39.1 ± 18.3 , respectively); however, fewer children achieved the MMA target (11.2%, $n = 1351$) than those who did not (15.8%, $n = 3271$) (Table 1).

Patients who attained AMR only or both HEDIS measures had a lower burden of comorbidities, as defined by the mean ($\pm$ SD) CCI (1.2 ± 1.1 vs 1.3 ± 1.3 than nonattainers; $P < .001$; Table 1). The prevalence of allergic rhinitis was higher

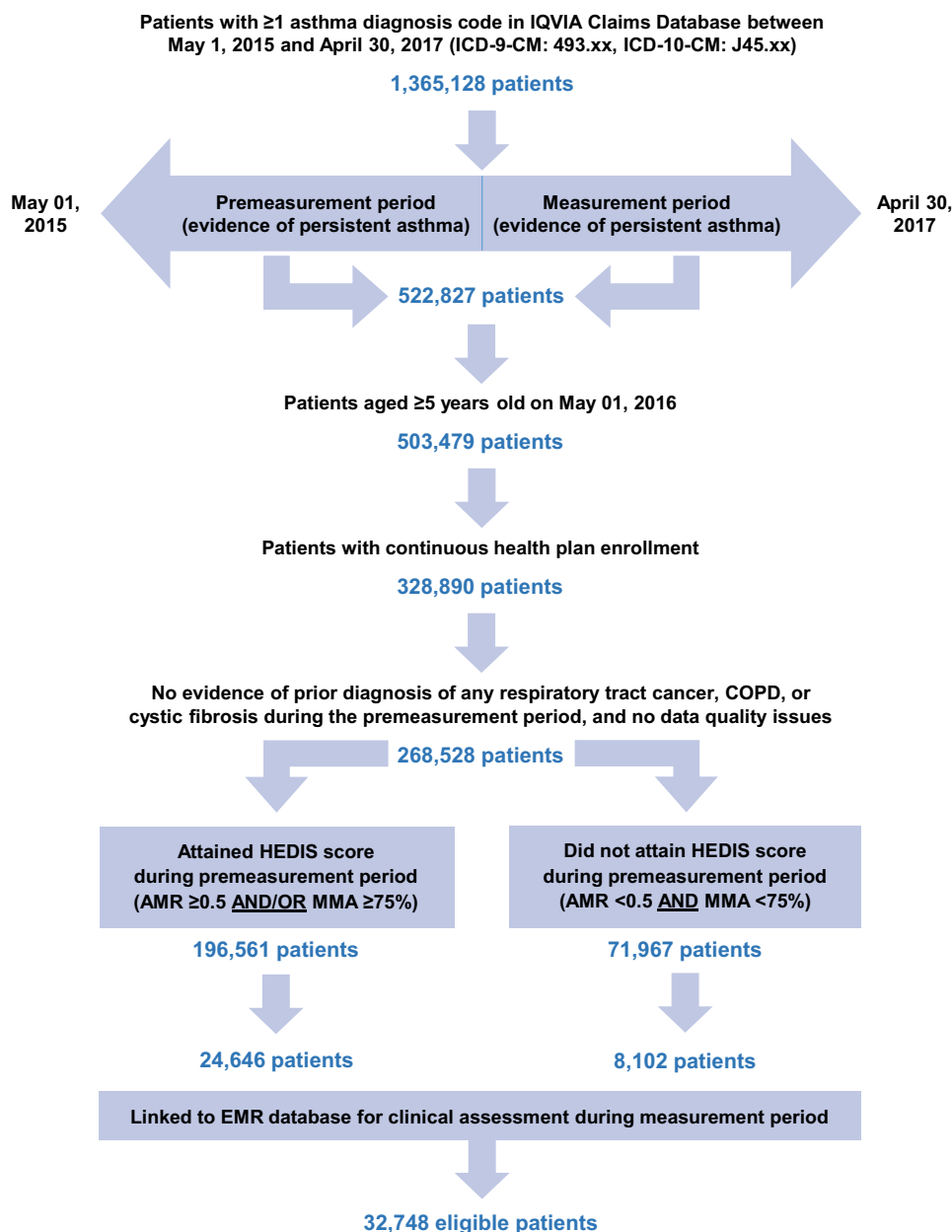


FIGURE 1. Patient attrition. *AMR*, Asthma medication ratio; *COPD*, chronic obstructive pulmonary disease; *EMR*, electronic medical records; *HEDIS*, health care effectiveness data and information set; *ICD-9-CM*, The International Classification of Diseases, Ninth Revision, Clinical Modification; *ICD-10-CM*, The International Classification of Diseases, Tenth Revision, Clinical Modification; *MMA*, medication management for people with asthma.

in HEDIS attainers than nonattainers and was notably higher in AMR attainers (32.6% vs 16.3%; $P < .001$) and MMA attainers (33.8% vs 25.3%; $P < .001$) compared with nonattainers (Table I).

During the premeasurement year, a high proportion of attainers and nonattainers of at least 1 HEDIS measure visited both a primary care physician (PCP) and an asthma specialist at least once (88.6% vs 86.9%; $P < .001$; Table II). Attainers of at least 1 HEDIS measure were less likely than nonattainers to have visited their PCP only (55.1% vs 69.3%; $P < .001$) and had a

greater number of visits to an asthma specialist only compared with nonattainers (4.3% vs 1.8%; $P < .001$).

Asthma medication use in the premeasurement period

AMR attainment was associated with more frequent use of controller medications in the premeasurement period (reported for attainers vs nonattainers): leukotriene modifiers (67.3% vs 15.8%), inhaled corticosteroids (ICS; 30.8% vs 21.8%), ICS/long-acting β -agonist (LABA) combinations (45.5% vs

TABLE I. Patient demographic and clinical characteristics during the premeasurement period

	AMR and/or MMA attainment during the premeasurement period			AMR attainment during the premeasurement period			MMA attainment during the premeasurement period		
	Attained AMR/MMA (N = 24,646)	Not-attained AMR/MMA (N = 8102)	P value	Attained AMR (N = 24,388)	Not-attained AMR (N = 8360)	P value	Attained MMA (N = 12,042)	Not-attained MMA (N = 20,706)	P value
Age (yr)									
Mean ± SD	41.5 ± 18.7	39.9 ± 17.0	<.001	41.4 ± 18.7	40.2 ± 17.0	<.001	44.6 ± 17.8	39.1 ± 18.3	<.001
Age category (y), n (%)			<.001			<.001			<.001
5-14	3703 (15.0)	919 (11.3)		3693 (15.1)	929 (11.1)		1351 (11.2)	3271 (15.8)	
15-74	20,830 (84.5)	7161 (88.4)		20,584 (84.4)	7407 (88.6)		10,628 (88.3)	17,363 (83.9)	
≥75	113 (0.5)	22 (0.3)		111 (0.5)	24 (0.3)		63 (0.5)	72 (0.3)	
Sex, n (%)			.0003			.0001			<.001
Female	15,326 (62.2)	4856 (59.9)		15,178 (62.2)	5004 (59.9)		7757 (64.4)	12,425 (60.0)	
Body mass index (kg/m ²)									
N (%)	6558 (26.6)	1845 (22.8)		6492 (26.6)	1911 (22.9)		3255 (27.0)	5148 (24.9)	
Mean ± SD	29.2 ± 8.1	29.9 ± 7.9	.001	29.2 ± 8.1	29.9 ± 7.9	.0003	30.1 ± 8.0	28.9 ± 8.1	<.001
Smoking status, n (%)			.5860			.6384			.0108
Smoker	3176 (12.9)	1053 (13.0)		3146 (12.9)	1083 (13.0)		1631 (13.5)	2598 (12.5)	
Nonsmoker	17,626 (71.5)	5824 (71.9)		17,440 (71.5)	6010 (71.9)		8513 (70.7)	14,937 (72.1)	
Unknown	3844 (15.6)	1225 (15.1)		3802 (15.6)	1267 (15.2)		1898 (15.8)	3171 (15.3)	
Race, n (%)			<.001			<.001			<.001
White	12,626 (51.2)	3597 (44.4)		12,499 (51.3)	3724 (44.5)		6379 (53.0)	9844 (47.5)	
African American	538 (2.2)	308 (3.8)		528 (2.2)	318 (3.8)		184 (1.5)	662 (3.2)	
Hispanic	122 (0.5)	77 (1.0)		120 (0.5)	79 (0.9)		41 (0.3)	158 (0.8)	
Asian	117 (0.5)	36 (0.4)		115 (0.5)	38 (0.5)		53 (0.4)	100 (0.5)	
Other	199 (0.8)	105 (1.3)		197 (0.8)	107 (1.3)		71 (0.6)	233 (1.1)	
Unknown	11,044 (44.8)	3979 (49.1)		10,929 (44.8)	4094 (49.0)		5314 (44.1)	9709 (46.9)	
Health plan type, n (%)			<.001			<.001			<.001
HMO	3631 (14.7)	2126 (26.2)		3564 (14.6)	2193 (26.2)		1456 (12.1)	4301 (20.8)	
Indemnity	208 (0.8)	50 (0.6)		207 (0.8)	51 (0.6)		119 (1.0)	139 (0.7)	
POS	853 (3.5)	264 (3.3)		843 (3.5)	274 (3.3)		425 (3.5)	692 (3.3)	
PPO	19,954 (81.0)	5662 (69.9)		19,774 (81.1)	5842 (69.9)		10,042 (83.4)	15,574 (75.2)	
Payer type, n (%)			<.001			<.001			<.001
Commercial	23,143 (93.9)	6807 (84.0)		22,928 (94.0)	7022 (84.0)		11,632 (96.6)	18,318 (88.5)	
Medicaid	1462 (5.9)	1269 (15.7)		1419 (5.8)	1312 (15.7)		398 (3.3)	2333 (11.3)	
Medicare	41 (0.2)	26 (0.3)		41 (0.2)	26 (0.3)		12 (0.1)	55 (0.3)	
Charlson Comorbidity Index (CCI)									
Mean ± SD	1.2 ± 1.1	1.3 ± 1.3	<.001	1.2 ± 1.1	1.3 ± 1.3	<.001	1.2 ± 1.1	1.2 ± 1.2	.4361
CCI category, n (%)			<.001			<.001			<.001
0	4545 (18.4)	1421 (17.5)		4501 (18.5)	1465 (17.5)		2366 (19.6)	3600 (17.4)	

(continued)

TABLE 1. (Continued)

	AMR and/or MMA attainment during the premeasurement period			AMR attainment during the premeasurement period			MMA attainment during the premeasurement period		
	Attained AMR/MMA	Not-attained AMR/MMA	P value	Attained AMR	Not-attained AMR	P value	Attained MMA	Not-attained MMA	P value
1	14,971 (60.7)	4808 (59.3)		14,832 (60.8)	4947 (59.2)		6885 (57.2)	12,894 (63.2)	
2	2688 (10.9)	946 (11.7)		2644 (10.8)	990 (11.8)		1463 (12.1)	2171 (10.5)	
3	1489 (6.0)	475 (5.9)		1469 (6.0)	495 (5.9)		793 (6.6)	1171 (5.7)	
4+	953 (3.9)	452 (5.6)		942 (3.9)	463 (5.5)		535 (4.4)	870 (4.2)	
Other notable comorbidities, n (%)									
Rheumatoid arthritis	2838 (11.5)	745 (9.2)	<.001	2801 (11.5)	782 (9.4)	<.001	1564 (13.0)	2019 (9.8)	<.001
Allergic rhinitis	7992 (32.4)	1321 (16.3)	<.001	7947 (32.6)	1366 (16.3)	<.001	4073 (33.8)	5240 (25.3)	<.001
Chronic sinusitis	3446 (14.0)	843 (10.4)	<.001	3425 (14.0)	864 (10.3)	<.001	1699 (14.1)	2590 (12.5)	<.001
Obstructive sleep apnea	577 (2.3)	373 (4.6)	<.001	572 (2.3)	378 (4.5)	<.001	304 (2.5)	646 (3.1)	.002
Gastroesophageal reflux disease	5452 (22.1)	1532 (18.9)	<.001	5399 (22.1)	1585 (19.0)	<.001	2937 (24.4)	4047 (19.5)	<.001
Eczema/atopic dermatitis	2172 (8.8)	678 (8.4)	.218	2154 (8.8)	696 (8.3)	.156	1020 (8.5)	1830 (8.8)	.2551

Although missing data were not imputed, an exception was made for race data. As a large proportion of patients had missing race information, a separate "unknown" category was created for these patients and they were included in the analyses.

AMR, Asthma medication ratio; HMO, health maintenance organization; MMA, medication management for people with asthma; PPO, preferred provider organization; POS, point of service; SD, standard deviation.

23.5%), and biologics (omalizumab, mepolizumab, and reslizumab; 1.4% vs 0.2%); all $P < .001$. However, AMR attainers used fewer SCS (47.9% vs 60.3%; $P < .001$) and short-acting β -agonists (SABA) (65.7% vs 90.8%; $P < .001$) compared with nonattainers, with 16.7% of nonattainers using a SABA as their sole asthma medication therapy.

Similarly, patients attaining MMA were more likely to use controller medications. The most frequently used controller medications in MMA attainers (vs nonattainers) were leukotriene modifiers (83.4% vs 37.1%), ICS/LABA combinations (43.8% vs 37.6%), and biologics (omalizumab, mepolizumab, and reslizumab; 1.3% vs 0.9%); all $P < .001$. Over one-third (35.0%) of MMA attainers used leukotriene modifiers as their only controller medication. Commonly used medications by patients who did not attain target MMA included SABA rescue medication (61.5% of attainers vs 78.3% of nonattainers; $P < .001$) and SCS (44.6% of attainers vs 54.8% of nonattainers; $P < .001$).

Attainment of HEDIS measures during the measurement period

A similar proportion of patients achieved HEDIS measures during the premeasurement period compared with the subsequent measurement period (99.0% vs 93.0% for AMR and 48.9% vs 44.9% for MMA). The time to AMR attainment took longer for those who did not previously attain AMR than for those who had previously attained this target during the previous premeasurement year (mean 286.6 vs 245.8 days; $P < .001$).

All-cause HRU during the measurement period

Regardless of HEDIS attainment status, most patients with persistent asthma (99%) had at least 1 outpatient visit during the 12-month measurement period. The mean number of outpatient visits per patient was similar in the cohort who attained at least 1 HEDIS measure (20.7 vs 20.0; $P = .02$), and among AMR attainers (20.6 vs 20.0; $P = .09$), compared with nonattainers. However, outpatient visits were significantly higher among MMA attainers than nonattainers (21.4 vs 19.8; $P < .001$).

When evaluating any type of HRU, fewer patients who achieved at least 1 satisfactory HEDIS measure had ≥ 1 hospitalizations (7.4% vs 11.6%; $P < .001$) or ED visit (24.7% vs 38.2%; $P < .001$) compared with nonattainers. This pattern was reflected in patients grouped by the attainment of individual AMR or MMA measures (Figure 2, A).

Asthma-related HRU and events during the measurement period

Patients attaining at least 1 HEDIS measure had lower asthma-related HRU than nonattainers, with fewer patients experiencing ≥ 1 asthma-related hospitalizations (4.9% vs 7.3%; $P < .001$), a shorter length of inpatient stay per patient (0.2 vs 0.3 days; $P < .001$), and fewer patients with ≥ 1 asthma-related ED visits (9.6% vs 18.2%; $P < .001$). There were also fewer patients with SCS bursts among those attaining at least 1 HEDIS measurement (43.8% vs 51.6%; $P < .001$), compared with nonattainers. Similarly, fewer patients with asthma-related events were recorded among attainers of individual AMR or MMA measures than nonattainers ($P < .001$ for all measures; Figure 2, B).

In multivariate logistic regression analyses, the attainment of at least 1 HEDIS measure was associated with a significantly lower likelihood of asthma exacerbation (odds ratio [OR]: 0.63,

TABLE II. Physician-type health care utilization during the premeasurement period

	AMR and/or MMA attainment during the premeasurement period			AMR attainment during the premeasurement period			MMA attainment during the premeasurement period		
	Attained AMR/MMA	Not-attained AMR/MMA	<i>P</i> value	Attained AMR	Not-attained AMR	<i>P</i> value	Attained MMA	Not-attained MMA	<i>P</i> value
	(N = 24,646)	(N = 8102)		(N = 24,388)	(N = 8360)		(N = 12,042)	(N = 20,706)	
≥1 PCPs and/or ≥1 asthma specialist visits, n (%)	21,835 (88.6)	7040 (86.9)	<.001	21,631 (88.7)	7244 (86.7)	<.001	10,618 (88.2)	18,257 (88.2)	1.00
PCP + asthma specialist visit, n (%)	7206 (29.2)	1284 (15.8)	<.001	7164 (29.4)	1326 (15.9)	<.001	3494 (29.0)	4996 (24.1)	<.001
PCP + pulmonologist visit, n (%)	2687 (10.9)	673 (8.3)	<.001	2661 (10.9)	699 (8.4)	<.001	1372 (11.4)	1988 (9.6)	<.001
PCP + allergist and immunologist visit, n (%)	4987 (20.2)	692 (8.5)	<.001	4966 (20.4)	713 (8.5)	<.001	2374 (19.7)	3305 (16.0)	<.001
PCP visit only, n (%)	13,575 (55.1)	5613 (69.3)	<.001	13,420 (55.0)	5768 (69.0)	<.001	6609 (54.9)	12,579 (60.8)	<.001
Asthma specialist visit only, n (%)	1054 (4.3)	143 (1.8)	<.001	1047 (4.3)	150 (1.8)	<.001	515 (4.3)	682 (3.3)	<.001
Pulmonologist visit only, n (%)	285 (1.2)	41 (0.5)	<.001	282 (1.2)	44 (0.5)	<.001	147 (1.2)	179 (0.9)	.002
Allergist and immunologist visit only, n (%)	801 (3.3)	103 (1.3)	<.001	796 (3.3)	108 (1.3)	<.001	383 (3.2)	521 (2.5)	.001
Pulmonologist + allergist and immunologist visit, n (%)	32 (0.1)	1 (0.0)	.004	31 (0.1)	2 (0.0)	0.01	15 (0.1)	18 (0.1)	.30
No. of unique asthma specialist visits*, mean ± SD	2.0 ± 6.2	0.8 ± 3.7	<.001	2.0 ± 6.2	0.8 ± 3.7	<.001	2.1 ± 6.3	1.5 ± 5.3	<.001
No. of unique pulmonologist visits*, mean ± SD	0.3 ± 1.0	0.2 ± 1.0	.03	0.3 ± 1.0	0.2 ± 1.0	.07	0.3 ± 1.0	0.3 ± 1.0	.14
No. of unique allergist and immunologist visits*, mean ± SD	1.8 ± 6.0	0.6 ± 3.0	<.001	1.8 ± 6.0	0.6 ± 3.0	<.001	1.8 ± 6.0	1.3 ± 5.0	<.001
No. of unique PCP visits*, mean ± SD	4.2 ± 5.0	4.5 ± 5.0	<.001	4.2 ± 5.0	4.5 ± 5.0	<.001	4.1 ± 5.0	4.3 ± 5.0	<.001

AMR, asthma medication ratio; CI, confidence interval; MMA, medication management for people with asthma; PCP, primary care physician; SD, standard deviation.

*A unique visit was defined as a visit on a unique date of service.

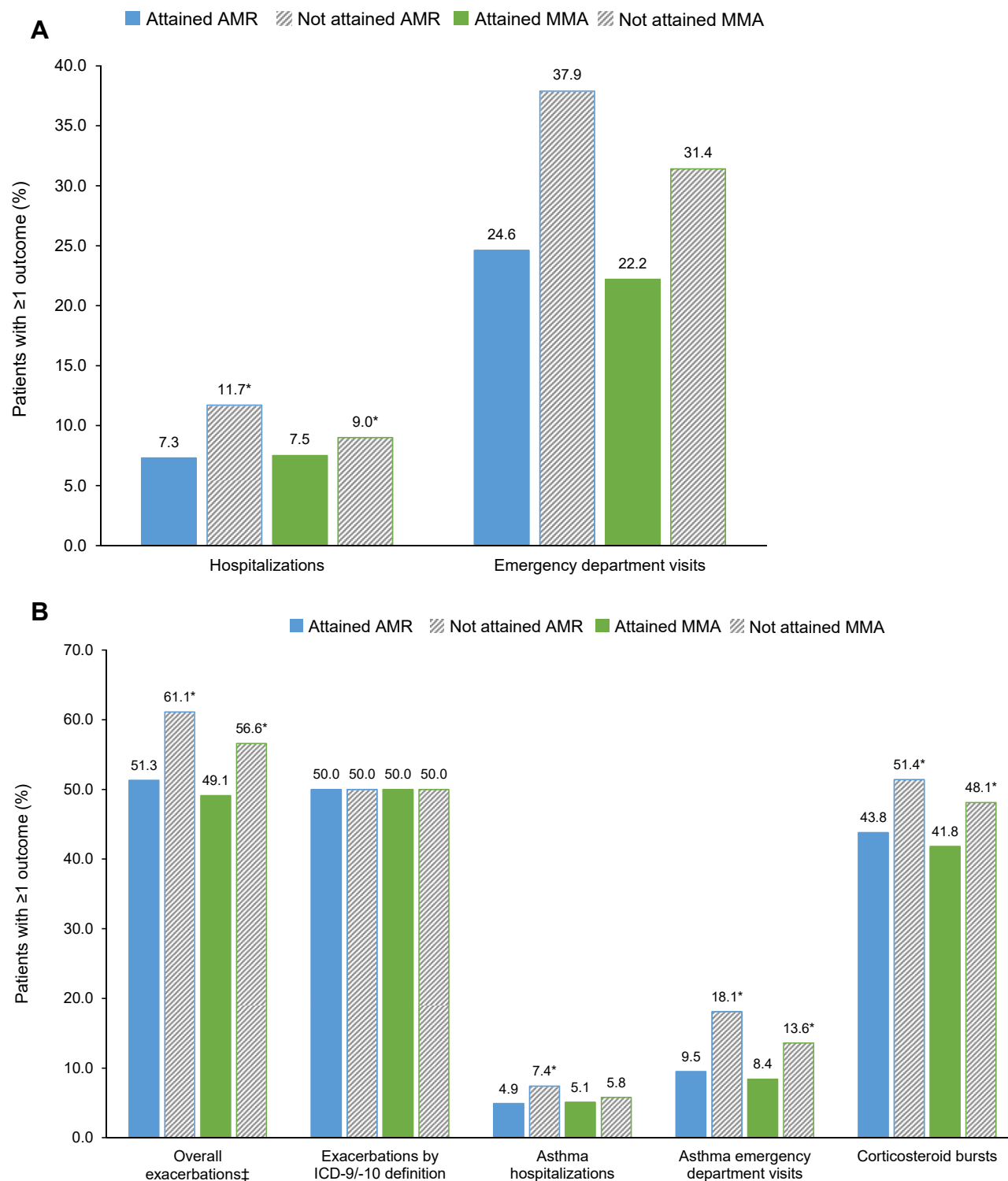


FIGURE 2. (A) Overall health care resource utilization and **(B)** asthma-related health care resource utilization and events during measurement period in patients stratified by HEDIS measurements. *Indicates statistical significance versus attained cohorts at $P < .001$. ‡Patients with ≥ 1 exacerbations. Asthma exacerbation by ICD-9/-10 definition = any claim or appearance in EMR with ICD-9-CM codes 493.02, 493.12, 493.22, 493.92, or ICD-10-CM codes J45.21, J44.1, J45.901 or an asthma hospitalization, asthma emergency department visit, or corticosteroid burst. AMR, Asthma medication ratio; EMR, electronic medical records; HEDIS, health care effectiveness and data information set; ICD-9-CM, The International Classification of Diseases, Ninth Revision, Clinical Modification; ICD-10-CM, The International Classification of Diseases, Tenth Revision, Clinical Modification; MMA, medication management for people with asthma.

TABLE III. Multivariate analyses of health care costs (per patient) during the measurement period in patients stratified by HEDIS measurements attained during the premeasurement period: odds ratios for exacerbations by AMR and/or MMA attainment

HEDIS measurement attainment during the premeasurement period	Original model		New model AMR vs no AMR		New model MMA vs no MMA	
	Odds ratio (95% CI)	P value	Odds ratio (95% CI)	P value	Odds ratio (95% CI)	P value
AMR and/or MMA attainment vs not attained	0.63 (0.60-0.67)	<.001				
AMR attainment vs AMR nonattainment (regardless of MMA attainment)			0.64 (0.60-0.67)	<.001		
MMA attainment vs MMA nonattainment (regardless of AMR attainment)					0.72 (0.68-0.75)	<.001

Covariates included in the regression: HEDIS measure attainment during the premeasurement period, age, sex, race, region, health plan type (PPO vs HMO), payer type (Medicaid/Medicare vs commercial), visit to asthma specialist during baseline, Charlson Comorbidity Index, smoker, relevant comorbidities during the premeasurement period (anemia, depression, hypertension, obstructive sleep apnea, rheumatoid arthritis, allergic rhinitis, chronic sinusitis, gastroesophageal reflux disease, and eczema/atopic dermatitis).

AMR, Asthma medication ratio; CI, confidence interval; HEDIS, health care effectiveness data and information set; HMO, health maintenance organization; MMA, medication management for people with asthma; PPO, preferred provider organization.

95% confidence interval [CI]: 0.60-0.67; $P < .001$) (Table III). Similarly, the likelihood of asthma exacerbation was 30% lower in AMR attainers (OR: 0.70; 95% CI: 0.66-0.74; $P < .001$) and 21% lower in MMA attainers (OR: 0.79; 95% CI: 0.61-1.02; $P = .07$), in comparison with respective nonattainers.

Health care costs associated with the attainment of HEDIS measures

Overall, patients attaining at least 1 HEDIS measure during the premeasurement period incurred 13% (95% CI: 10-15) lower total costs compared with nonattainers. Total mean health care costs per patient were lower in AMR attainers versus nonattainers (\$14,747 vs \$17,804), as were total medical costs (\$8747 vs \$11,600), and costs associated with inpatient (\$2345 vs \$4053), outpatient (\$5993 vs \$6820), and ED (\$409 vs \$727) visits ($P < .001$ for all; Figure 3, A). Asthma exacerbation-related health care costs were significantly lower with AMR attainment (\$1391 vs \$2021 for nonattainers; $P < .001$).

Total health care costs were \$925 higher per patient with MMA attainment versus those not attaining MMA (\$16,112 vs \$15,187; $P = .02$; Figure 3, A). Costs per patient associated with inpatient (\$2570 vs \$2904; $P = .10$) and outpatient care (\$6193 vs \$6210; $P = .91$) were not statistically significantly different between MMA groups, although ED visit costs were elevated in MMA nonattainers (\$373 vs \$558; $P < .001$; Figure 3, A). Likewise, total asthma exacerbation-related costs during the measurement period did not differ significantly between MMA attainers and nonattainers (\$1469 vs \$1600; $P = .19$).

Medication costs associated with the attainment of HEDIS measures

Although the mean number of overall prescriptions per patient (for all indications) was lower among AMR attainers compared with nonattainers (43.2 vs 46.1; $P < .001$), all-cause medications costs per patient were similar among both attainers and nonattainers (\$6000 vs \$6203; $P = .35$; Figure 3, B).

With asthma as any diagnosis (consistent with ICD-9/10 definition), total asthma-related health care costs were significantly lower among AMR attainers versus nonattainers (\$2545 vs \$2967 per patient; $P = .001$; Figure 3, A). However, there were higher costs per patient for AMR attainers for asthma biologic costs (\$343 vs \$73 for nonattainers; $P < .001$) and other asthma medication costs (\$1457 vs \$1041; $P < .001$), but a lower mean

cost per patient for nonasthma-related medications (\$4202 vs \$5091; $P < .001$), compared with nonattainers.

Patients in the MMA attainment group had a higher number of overall prescriptions per patient for any indication (48.9 vs 41.0 for nonattainers; $P < .001$) and had higher all-cause medication costs than nonattainers (\$6976 vs \$5515; $P < .001$; Figure 3, B). With asthma as any diagnosis, total asthma-related health care costs were similar between MMA attainers and nonattainers (\$2623 vs \$2670; $P = .69$).

Associations between HEDIS measure attainment and health care costs per patient

Adjusted analyses indicated that the attainment of at least 1 HEDIS measure was associated with lower total health care costs (cost ratio: 0.87, 95% CI: 0.85-0.90; $P < .001$), lower asthma-related health care costs (cost ratio: 0.96; 95% CI: 0.93-0.99; $P = .02$), and lower exacerbation health care costs (cost ratio: 0.59; 95% CI: 0.55-0.64; $P < .001$; Table IV).

For each individual HEDIS measure, adjusted analyses found that AMR attainment was associated with lower total health care costs (cost ratio: 0.85, 95% CI: 0.83-0.87; $P < .001$), asthma-related health care costs (cost ratio: 0.93, 95% CI: 0.90-0.96; $P < .001$), and asthma exacerbation-related health care costs (cost ratio: 0.43, 95% CI: 0.40-0.46; $P < .001$). By contrast, MMA attainment did not impact either total health care costs (cost ratio: 1.00, 95% CI: 0.97-1.02; $P = .75$) or asthma-related health care costs (cost ratio: 1.02, 95% CI: 0.99-1.05; $P = .30$), but was associated with a significant reduction in asthma exacerbation-related health care costs (cost ratio: 0.76, 95% CI: 0.72-0.82; $P < .001$; Table IV).

DISCUSSION

These analyses suggest that the attainment of HEDIS asthma measures (AMR and/or MMA) was associated with improved clinical outcomes, reduced HRU, and lower asthma-related health care costs.

Most patients achieved target AMR in the premeasurement period, whereas only 37% of patients achieved the more stringent MMA threshold, and 25% of patients achieved neither measure. Attainers tended to be older and more likely to have comorbid conditions such as allergic rhinitis, chronic sinusitis, and rheumatoid arthritis. They were more likely to have visited an asthma specialist at least once (in addition to their PCP) and

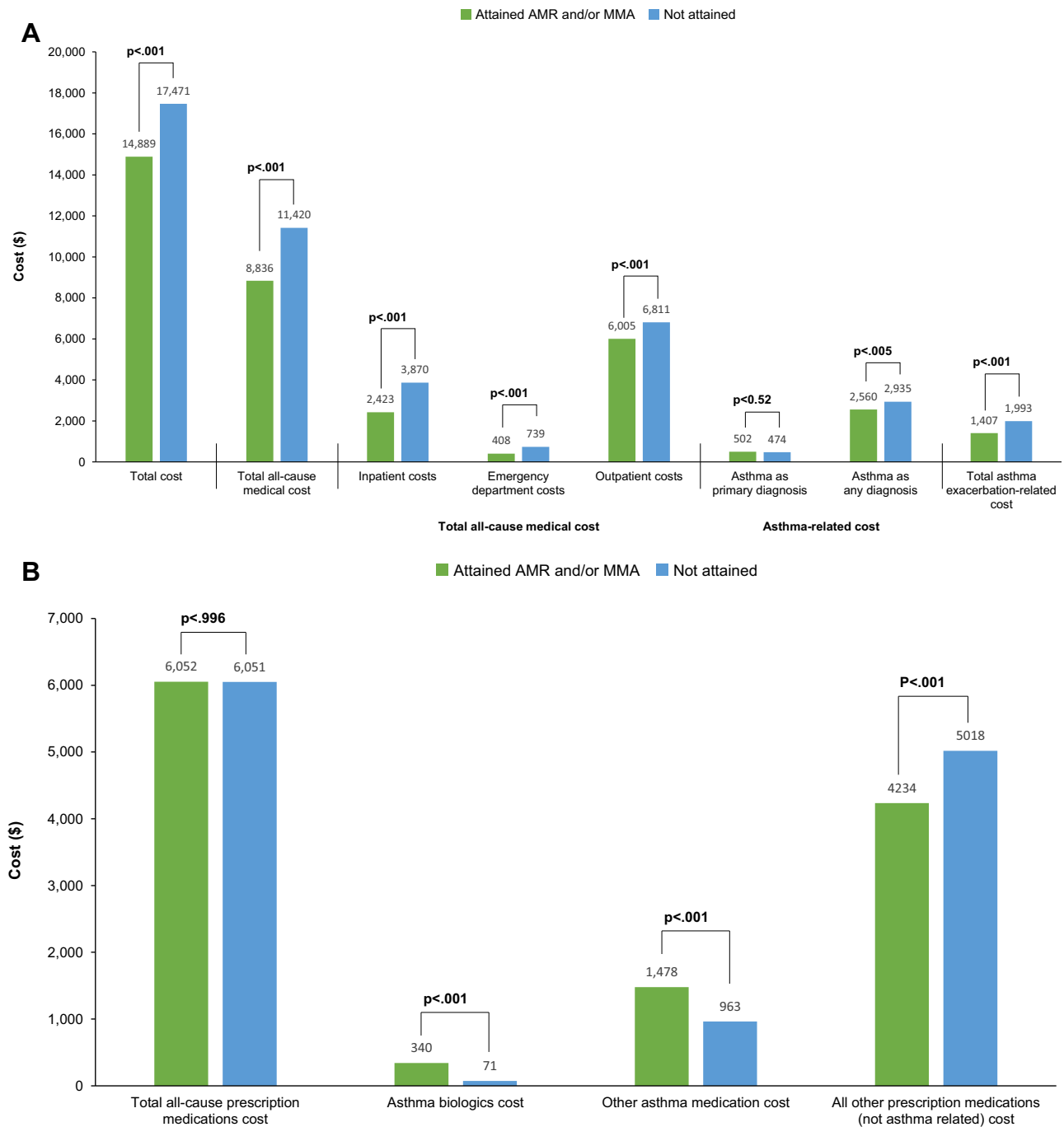


FIGURE 3. Health care costs (per patient) during the measurement period in patients stratified by HEDIS measurements attained during the premeasurement period for **(A)** total all-cause and asthma-related medical cost and **(B)** total all-cause and asthma-related medication costs. *AMR*, Asthma medication ratio; *HEDIS*, health care effectiveness and data information set; *MMA*, medication management for people with asthma.

more likely to continue attaining HEDIS measures in the subsequent measurement period, suggesting a better quality of care through closer monitoring of adherence to medication, which may have persistent effects on long-term outcomes.

These findings indicate that patients who achieved HEDIS asthma quality measures in the previous year had improved clinical outcomes in the following year, compared with nonattainers. Improvements included significantly fewer asthma

exacerbations, asthma-related hospitalizations, and ED visits, shorter inpatient stays, and lower prevalence of SCS bursts. Health care costs were lower among attainers than nonattainers of at least 1 HEDIS measure.

The attainment of AMR and MMA individually was associated with better clinical outcomes and lower HRU in this analysis, but only AMR attainment (and not MMA) was associated with lower overall health care costs in multivariate analysis.

TABLE IV. Multivariate analyses of health care costs (per patient) during the measurement period in patients stratified by HEDIS measurements attained during the premeasurement period: health care cost ratios according to AMR and/or MMA attainment

Costs per patient	HEDIS measurement attainment during the premeasurement period					
	AMR and/or MMA attainment		AMR attainment		MMA attainment	
	Cost ratio (95% CI)	<i>P</i> value	Cost ratio (95% CI)	<i>P</i> value	Cost ratio (95% CI)	<i>P</i> value
Total health care	0.87 (0.85-0.90)	<.001	0.85 (0.83-0.87)	<.001	1.00 (0.97-1.02)	.75
Asthma-related health care	0.96 (0.93-0.99)	.02	0.93 (0.90-0.96)	<.001	1.02 (0.99-1.05)	.30
Asthma exacerbation—related health care	0.59 (0.55-0.64)	<.001	0.43 (0.40-0.46)	<.001	0.76 (0.72-0.82)	<.001

Covariates included in the regression: HEDIS measure attainment during the premeasurement period, age, sex, race, region, health plan type (PPO vs HMO), payer type (Medicaid/Medicare vs commercial), visit to asthma specialist during baseline, Charlson Comorbidity Index, smoker, relevant comorbidities during the premeasurement period (anemia, depression, hypertension, obstructive sleep apnea, rheumatoid arthritis, allergic rhinitis, chronic sinusitis, gastroesophageal reflux disease, and eczema/atopic dermatitis).

AMR, Asthma medication ratio; CI, confidence interval; HEDIS, health care effectiveness data and information set; HMO, health maintenance organization; MMA, medication management for people with asthma; PPO, preferred provider organization.

Notably, AMR, unlike MMA, takes asthma control into account, as measured by SABA use. High AMRs indicate a combination of higher use of controller medication and lower use of rescue medication; therefore, the attainment of AMR targets might indicate the appropriate escalation of controller therapy. However, as MMA attainment directly relates to having an asthma controller medication and does not measure how well controlled a patient is, it may be a poor indicator of optimal asthma management. For example, patients with poorly controlled disease (requiring frequent rescue medication) appear to have been maintained on leukotriene modifiers or an ICS, when evidence suggests they should have been escalated to an ICS/LABA or high-dose ICS. This is partially supported by higher use of leukotriene receptor antagonists as controller medication in MMA attainers who used leukotriene receptor antagonist 87% of the time. Without adjustment for premeasurement covariates, such as asthma severity, it is difficult to determine the true impact of MMA attainment on costs, and interpreting the value of MMA as an asthma quality measure requires further study.

The attainment of AMR was associated with increased asthma medication costs but decreased overall medication costs. Better asthma control may be associated with reduced use of other medications to treat complications of uncontrolled asthma, such as diabetes, hypertension, and infections such as pneumonia.²⁷ Patients who attained AMR targets were more likely to visit their PCP in addition to an allergist, immunologist, or pulmonologist, suggesting the value of these specialists in helping patients attain the HEDIS measures or conversely that these quality indicators help patients keep doctor appointments and increase adherence to medication.

Our findings mostly agree with previous studies (largely using AMR targets) with similar proportions of patients attaining AMR and MMA in our study as in previous studies.^{22,23} Specifically, previous studies reported a lower incidence of asthma-related hospitalizations and ED visits, fewer asthma exacerbations, and lower all-cause nonmedication health care costs in AMR attainers compared with nonattainers.^{22,25,28,29} Some of our findings contrast with a separate database analysis in which AMR attainment was associated with higher total health care costs than nonattainment (largely driven by higher medication costs).²⁸ However, in agreement with our analyses, AMR attainment was also associated with a lower prevalence of SCS bursts, ED

visits, hospitalizations, and lower nonmedication-related health care.²⁸ Furthermore, Zeiger et al³⁰ reported associations between AMR attainment and higher total and asthma-related health care costs. Although Yoon et al²³ reported that attaining a satisfactory MMA score was not significantly associated with improved clinical outcomes, data on MMA attainment and clinical outcomes are sparse. These findings suggest the need for further investigation into associations between AMR, MMA, and health care costs.

The main strength of our study is the large patient population in which analyses were conducted. In addition, the database is representative of the US population across geographies and Medicare as well as commercial insurance. However, interpretation is limited by the retrospective, observational study design and the fact that the data were not collected for research purposes. The inclusion criteria for this study stipulated patients meeting at least one of the HEDIS criteria for persistent asthma during both the premeasurement and measurement years, and hence asthma events in the measurement year could influence patient eligibility and bias toward those with events during the measurement year. Among patients in our study sample, 71.9% were defined as having persistent asthma because they met the criterion of having had at least 4 asthma medication dispensing events in a 12-month period, as opposed to meeting one of the other 3 criteria. This criterion is not directly relevant to the key outcomes of this study, such as asthma exacerbations. Hence, we consider that the findings from this study are still valid despite this limitation. However, bias remains possible due to the use of the measurement year as an inclusion year. Another limitation, typical of retrospective database analyses, is the presence of missing data and unavailability of endpoint data for some patients.

In summary, this analysis indicates that the attainment of HEDIS measures is associated with better clinical outcomes and reduced health care costs in general (although not for MMA). Our data suggest that cost savings may arise from a lower level of asthma medication use/adherence (sufficient for AMR attainment) than is needed to attain MMA. More broadly, our findings highlight the importance of monitoring adherence to and persistence with asthma treatment, and suggest that partnership between PCPs and asthma specialists may help to achieve quality metrics, reduce exacerbations, and ultimately lower HRU in people with persistent asthma.

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TABLE E1. Additional patient demographic and clinical characteristics during the premeasurement period

	AMR and/or MMA attainment during the premeasurement period			AMR attainment during the premeasurement period			MMA attainment during the premeasurement period		
	Attained AMR/MMA	Not-attained AMR/MMA	P value	Attained AMR	Not-attained AMR	P value	Attained MMA	Not-attained MMA	P value
	(N = 24,646)	(N = 8102)		(N = 24,388)	(N = 8360)		(N = 12,042)	(N = 20,706)	
Age category (y), n (%)			<.001			<.001			<.001
5-14	3703 (15.0)	919 (11.3)		3693 (15.1)	929 (11.1)		1351 (11.2)	3271 (15.8)	
15-24	2267 (9.2)	960 (11.8)		2253 (9.2)	974 (11.7)		899 (7.5)	2328 (11.2)	
25-34	1586 (6.4)	904 (11.2)		1568 (6.4)	922 (11.0)		684 (5.7)	1806 (8.7)	
35-44	3614 (14.7)	1473 (18.2)		3565 (14.6)	1522 (18.2)		1646 (13.7)	3441 (16.6)	
45-54	5760 (23.4)	1941 (24.0)		5683 (23.3)	2018 (24.1)		2988 (24.8)	4713 (22.8)	
55-64	7020 (28.5)	1760 (21.7)		6941 (28.5)	1839 (22.0)		4029 (33.5)	4751 (22.9)	
65-74	583 (2.4)	123 (1.5)		574 (2.4)	132 (1.6)		382 (3.2)	324 (1.6)	
Weight (lbs)									
N	6642 (26.9)	1868 (23.1)		6574 (27.0)	1936 (23.2)		3291 (27.3)	5219 (25.2)	
Mean ± SD	177.8 ± 66.6	186.1 ± 64.3	<.001	177.5 ± 66.6	186.6 ± 64.5	<.001	184.1 ± 64.8	176.7 ± 67.0	<.001
Other comorbidities, n (%)									
Anemia	1817 (7.4)	699 (8.6)	.001	1793 (7.4)	723 (8.6)	<.001	972 (8.1)	1544 (7.5)	.04
Depression	3798 (15.4)	1449 (17.9)	<.001	3752 (15.4)	1495 (17.9)	<.001	1927 (16.0)	3320 (16.0)	.94
Heart failure	383 (1.6)	176 (2.2)	.001	377 (1.5)	182 (2.2)	<.001	201 (1.7)	358 (1.7)	.69
Hypertension	7344 (29.8)	2347 (29.0)	.156	7241 (29.7)	2450 (29.3)	.51	4153 (34.5)	5538 (26.7)	<.001
Asthma control test score (ACT)									
N (%)	107 (0.4)	14 (0.2)		107 (0.4)	14 (0.2)		56 (0.5)	65 (0.31)	
Mean ± SD	21.5 ± 3.7	20.1 ± 3.9	.20	21.5 ± 3.7	20.1 ± 3.9	.20	21.9 ± 3.5	20.8 ± 3.9	.11
ACT <19, n (%)	20 (18.7)	5 (35.7)	.16	20 (18.7)	5 (35.7)	.16	9 (16.1)	16 (24.6)	.25
ACT ≥20, n (%)	87 (81.3)	9 (64.3)	.16	87 (81.3)	9 (64.3)	.16	47 (83.9)	49 (75.4)	.25
Eosinophil count (EOS)									
N (%)	84 (0.3)	19 (0.2)		84 (0.3)	19 (0.2)		53 (0.4)	50 (0.2)	
Mean ± SD	265.6 ± 204.4	257.6 ± 209.7	.88	265.6 ± 204.4	257.6 ± 209.7	.88	259.2 ± 189.5	269.3 ± 220.8	.80
EOS <150, n (%)	28 (33.3)	7 (36.8)	.77	28 (33.3)	7 (26.8)	.77	19 (35.8)	16 (32.0)	.68
EOS ≥150 to <300, n (%)	28 (33.3)	4 (21.1)	.30	28 (33.3)	4 (21.1)	.30	17 (32.1)	15 (30.0)	.82
EOS ≥300, n (%)	28 (33.3)	4 (21.1)	.30	28 (33.3)	4 (21.1)	.30	17 (32.1)	15 (30.0)	.82
FEV ₁ (%)									
N (%)	8 (0.03)	3 (0.04)		8 (0.03)	3 (0.04)		4 (0.03)	7 (0.03)	
Mean ± SD	95.9 ± 11.8	89.7 ± 8.0	.43	95.9 ± 11.8	89.7 ± 8.0	.43	92.5 ± 14.9	95.1 ± 9.1	.72
FEV ₁ <80%, n (%)	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
FEV ₁ ≥80%, n (%)	8 (100.0)	3 (100.0)		8 (100.0)	3 (100.0)		4 (100.0)	7 (100.0)	
FVC									
N (%)	16 (0.06)	4 (0.05)		16 (0.07)	4 (0.05)		8 (0.07)	12 (0.06)	
Mean ± SD	61.8 ± 47.6	49.7 ± 54.7	.66	61.8 ± 47.6	49.7 ± 54.7	.66	60.8 ± 48.5	58.5 ± 49.4	.92
FEV ₁ /FVC ratio									
N (%)	27 (0.10)	4 (0.05)		27 (0.11)	4 (0.05)		7 (0.06)	24 (0.12)	
Mean ± SD	75.6 ± 20.2	74.0 ± 8.0	.88	75.6 ± 20.2	74.0 ± 8.0	.88	72.1 ± 17.4	76.4 ± 19.7	.61

AMR, Asthma medication ratio; FEV₁, forced expiratory volume in 1 second; FVC, forced vital capacity; MMA, medication management for people with asthma; SD, standard deviation.

TABLE E2. Asthma medication use during the premeasurement period*

Asthma medication category	Drug type	Drug name
Controllers	Immunomodulators	Mepolizumab
		Omalizumab
		Reslizumab
	Inhaled corticosteroid	Beclomethasone dipropionate
		Budesonide (inhalation)
		Ciclesonide
		Flunisolide
		Fluticasone furoate (inhalation)
		Fluticasone propionate (inhalation)
	Inhaled corticosteroids/long-acting β -agonists combination	Mometasone furoate (inhalation)
		Budesonide-formoterol fumarate dihydrate
		Fluticasone furoate-vilanterol
	Long-acting β -agonists	Fluticasone-salmeterol
		Mometasone furoate-formoterol fumarate dihydrate
		Formoterol
		Formoterol fumarate
		Salmeterol xinafoate
	Long-acting muscarinic receptor antagonists	Tiotropium bromide monohydrate
	Leukotriene modifiers	Montelukast sodium
		Zafirlukast
		Zileuton
	Mast cell stabilizers	Cromolyn sodium
	Methylxanthines	Aminophylline
		Dyphylline
		Dyphylline-guaifenesin
		Theophylline
		Theophylline in dextrose
		Theophylline sodium glycinate-GG
		Theophylline-PSE-GG
Quick-relief	Short-acting β -agonists	Albuterol
		Albuterol sulfate
		Levalbuterol HCl
		Levalbuterol tartrate
		Pirbuterol acetate
	Short-acting muscarinic-antagonist	Ipratropium bromide
		Ipratropium bromide HFA
	Short-acting muscarinic-antagonist/ short-acting β -agonists combination	Ipratropium-albuterol
		Ipratropium bromide-albuterol
		Ipratropium bromide-levabuterol
Others	Systemic corticosteroid	Betamethasone
		Cortisone acetate
		Dexamethasone
		Dexamethasone acetate
		Dexamethasone sodium phosphate
		Hydrocortisone
		Hydrocortisone sodium succinate
		Methylprednisolone
		Methylprednisolone sodium succinate
		Prednisolone
		Prednisolone acetate
		Prednisolone sodium phosphate
		Prednisone
		Triamcinolone

*Use defined as ≥ 1 claims for the medication.