

# Predicting Asthma Outcomes in Commercially Insured and Medicaid Populations

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**Objectives:** To assess the predictive ability of the ratio of controller-to-total asthma medication in commercially insured and Medicaid patients.

**Study Design:** Retrospective cohort.

**Methods:** Medical and pharmacy claims were used to identify asthma patients between 2004 and 2006. Ratios were computed during 3-, 6-, and 12-month assessment periods and asthma exacerbations were assessed during a subsequent 12-month follow-up period. Receiver operating characteristic curve analyses and logistic regression were used to select optimal ratio number, assessment time period, and incremental ratio analysis.

**Results:** The ratio significantly predicted future asthma exacerbations. An optimal value of  $\geq 0.7$  was identified in pediatric and adult Medicaid patients with a shorter assessment period in adults (3 months) than in children (6 months). In commercially insured patients, an optimal value of  $\geq 0.5$  during a 6-month assessment period was identified for children and adults. In commercially insured patients, a 0.1-unit increase in the ratio below the 0.5 value resulted in a 72% (odds ratio [OR] 0.28; 95% confidence interval [CI] 0.13-0.57) and 80% (OR 0.20; 95% CI 0.12-0.33) risk reduction among pediatric and adult patients, respectively. Similarly, a 0.1-unit increase in the ratio below the 0.7 optimal value in the Medicaid population resulted in significant risk reduction in the pediatric (OR 0.65; 95% CI 0.43-0.97) but not the adult cohort.

**Conclusions:** The ratio is a significant predictive risk marker in commercially insured and Medicaid asthma populations. Incremental risk reductions can be realized by unit increases in the ratio up to the identified optimal value.

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For author information and disclosures, see end of text.

Asthma represents a significant burden to the healthcare system. In 2008, almost half of the total current asthma population in the United States (12.7 of 23.3 million) experienced an asthma exacerbation, adversely affecting patients' quality of life and increasing the likelihood of hospitalizations and emergency department (ED) visits.<sup>1</sup> Consequently, efforts have been made to determine quality-of-care markers that can predict future exacerbations, particularly those requiring hospital or ED visits, in order to improve asthma management and reduce this burden.

One such measure, the Healthcare Effectiveness Data and Information Set (HEDIS), is based on the proportion of health plan members with persistent asthma who are appropriately prescribed long-term control medication at least once during a given year.<sup>2</sup> Although adherence to the HEDIS measure has been associated with a lower risk of hospital and ED visits,<sup>3,4</sup> it has shown to be an inconsistent predictor of asthma outcomes.<sup>5,6</sup>

Therefore, alternate measures have been proposed that more effectively assess asthma quality of care and that can more reliably predict the occurrence of exacerbations. One measure in particular, the ratio of controller-to-total asthma medication (ratio), has been shown to be a strong predictor of patient outcomes, asthma-related hospitalizations, and ED utilization,<sup>5,7-11</sup> and a better quality-of-care marker than the HEDIS measure.<sup>10</sup> Studies examining the predictive ability of this marker incorporate a 1-year measurement period that is consistent with the HEDIS performance measure. This period is valid given that the ratio might not be appropriate for patients who do not have persistent asthma. However, a 1-year measurement period prevents rapid interventional adjustments. It is not known whether a shorter measurement period would affect the predictive ability of the ratio. Because of the restrictive nature of the persistent asthma measure and the need for defining a population in a study with shorter observation times, an asthma population at risk for uncontrolled asthma or asthma exacerbations was defined for this study. At-risk patients were defined as those that meet the treatment and symptom (albuterol use as the proxy) criterion of having at least mild persistent asthma according to National Asthma Education and Prevention Program guidelines.<sup>2</sup>

Most of the studies on the ratio have been performed in persistent asthma patients from commercially insured databases

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across age groups. Studies in children and those from the Medicaid population are limited. It is important to study these populations because Medicaid patients are representative of a population that is more likely to have asthma and asthma-related adverse events, specifically individuals who are younger, are female, and have lower socioeconomic status.<sup>12-14</sup> Among those insured by Medicaid, a higher percentage of patients have asthma and poorer asthma control compared with those who have private insurance or are uninsured.<sup>15,16</sup> Medicaid coverage was found to be independently associated with poor asthma control in children, and controller medication underuse among Medicaid-covered children is widespread.<sup>17-20</sup> Studies have shown that children in Medicaid were more likely to be admitted to the ED or hospital for asthma compared with privately insured children.<sup>17,21</sup>

In this study we examined the predictive ability of the ratio in pediatric and adult populations at risk for asthma exacerbations using both commercially insured and Medicaid databases. The primary goal was to determine an optimal value for the ratio that is associated with a significant difference in predicting future exacerbations. We also examined the correlation between incremental unit changes in the ratio and the risk of having an exacerbation. Lastly, we identified an optimal time frame for measuring the ratio to accurately predict the risk of future exacerbations.

## METHODS

### Study Population and Design

This study was a retrospective analysis of 2 databases, the Ingenix Impact National Managed Care Database (commercially insured) and the MarketScan Medicaid Database. The data used were from January 1, 2003, to either June 30, 2007 (Medicaid), or June 30, 2008 (commercially insured). The commercially insured database utilized the integrated medical and pharmacy administrative claims of more than 98 million lives spanning 9 census regions. The Medicaid database utilized nearly 22 million enrollees across 6 states. The initial study population identified included patients with at least 1 pharmacy claim for any type of asthma medication excluding oral corticosteroids (OCSs) during the enrollment period from January 1, 2004, to either June 30, 2005 (Medicaid), or June 30, 2006 (commercially insured). The 1-year period before the enrollment period (preindex period) was used for baseline assessment and to ensure the presence of asthma. The postindex period had 2 parts: 1 to calculate the ratio (the optimal assessment period) and a subsequent 12-month

### Take-Away Points

This study examined the predictive ability of the controller-to-total asthma medication ratio in pediatric and adult commercially insured and Medicaid patients.

- The ratio significantly predicted future asthma exacerbations in both populations.
- Incremental risk reductions could be realized by unit increases in the ratio up to the identified optimal value.

follow-up period. The optimal assessment period was varied using 3-, 6-, and 12-month periods to allow for sufficient time to accurately calculate the ratio.

All patients identified as the initial study population were also required to meet the following study criteria: have at least 1 medical claim with an asthma diagnosis (*International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM]* code 493.xx) in any diagnosis field during the preindex period or 30 days after the index date; be continuously eligible to receive medical and pharmacy services in the 1-year preindex period and 24-month postindex period; be at least 4 years of age at the index date; and have no diagnosis of chronic obstructive pulmonary disease (codes 491.xx, 492.xx, 496.xx) anytime during the preindex and postindex periods.

Patients at risk for asthma exacerbation constituted a subset of this initial study population meeting all study criteria. The definition of “at risk for asthma exacerbation” for this study was based on medication use and differed based on the length of the assessment period. Accordingly, the number of patients identified as being at risk for asthma exacerbation differed for each assessment period. Patients were considered to be at risk for asthma exacerbation if they had  $\geq 1$  dispensing event for an asthma controller medication or  $\geq 2$  short-acting beta-agonist (SABA) canisters for the 3-month period;  $\geq 1$  dispensing event for an asthma controller medication or  $\geq 4$  SABA canisters for the 6-month period; or  $\geq 1$  dispensing event for an asthma controller medication or  $\geq 5$  SABA canisters for the 12-month period. By requiring patients to have at least 1 controller medication or SABA use during the assessment periods, we reduced the likelihood of having missing ratio values (ie, no controller or SABA use) or many zero values (ie, no controller but only SABA use). Including patients with missing ratio values or many zero values would have increased the likelihood of including patients with intermittent asthma. Since the ratio is only reliable in patients with persistent asthma, inclusion of patients with intermittent asthma would affect the overall reliability of the marker.

### Study Variables

The controller-to-total asthma medication ratio was calculated as the ratio of the units of controller medications used divided by the sum of the units of the controller medications,

plus the units of inhaled SABAs. Controller medications included inhaled corticosteroids (ICSs), ICS and long-acting beta-agonist (LABA) combination products, leukotriene modifiers, cromolyn sodium, nedocromil, methylxanthines, and omalizumab. The ratio ranged from 0 (no controller + SABA) to 1 (controller + no SABA). Patients using no medications or using only LABAs during the assessment periods would have had missing ratio values and were excluded. As previously described,<sup>22</sup> 1 unit of medication was defined as (1) 1 canister of an inhaler, (2) a 30-day supply of an oral medication, or (3) 1 dispensing of a nebulized or injected medication.

### Study Outcomes

The primary outcome was an asthma exacerbation requiring an inpatient hospitalization or ED visit with a primary discharge diagnosis of asthma (ICD-9-CM code 493.xx) during the 12-month follow-up period. We selected the optimal ratio value, the assessment period, and the incremental risk-change analysis using this primary outcome. We evaluated the impact of the optimal ratio value and assessment period on exacerbations, individual components of the exacerbations (ie, inpatient hospitalization, ED visits), and OCS-dispensing events.

### Statistical Analysis

The final study sample was split into pediatric (4-17 years) and adult ( $\geq 18$  years) cohorts. The same analysis was conducted on both cohorts. A receiver operating characteristic (ROC) curve analysis was done to select the optimal cutoff of the ratio. The ROC analysis was done only with the primary outcome of exacerbations during a 12-month follow-up period. The cutoff values for the ratio ranged from  $\geq 0.1$  to  $\geq 0.9$  at 0.1 intervals. The ROC analysis compared the areas under the curve (AUCs) obtained from the C statistic of the logistic regression model that was run for each cutoff value. All logistic regression models controlled for baseline characteristics during the preindex period (age, sex, Charlson Comorbidity Index,<sup>23</sup> number of unique diagnosis codes, number of unique prescription drug categories, number of unique prescriptions filled) and asthma severity (presence of asthma-related hospitalizations or ED visits, number of OCS-dispensing events) during the assessment period. To select the optimal cutoff value within an assessment period, we considered the model that had the highest AUC and that showed a statistically significant effect of the ratio on the outcome. After selecting the optimal cutoff within each assessment period, the choice of an assessment period was based on a statistical comparison of the AUCs of the models selected for each of the 3 assessment periods. The following steps were used for this comparison. The highest AUC was compared with the lowest. If the difference was not statistically significant, then the shorter assessment

period was chosen with its respective cutoff value. If, however, the difference was statistically significant, then the comparison was repeated with the next-lowest AUC.

For the incremental risk-change analysis, the presence of a linear relationship was first demonstrated with a significant linear trend statistical test result and a graphical analysis showing an increasing or decreasing odds ratio (OR) with an increase in the ratio values.<sup>24,25</sup> If a linear relationship was found, the ratio was entered into a logistic regression model as a continuous variable, adjusting for baseline characteristics and asthma severity as described above. The OR was then interpreted as the percent decrease or increase in risk of the outcome with each unit increase in the ratio value.

After selection of the optimal cutoff value and assessment period, multivariate logistic regression models were developed to predict the likelihood of the other outcomes during the follow-up period as a function of the optimal cutoff of the ratio, while controlling for baseline characteristics during the preindex period and asthma severity during the assessment period as described above. Adjusted ORs with corresponding 95% confidence intervals (CIs) are presented.

## RESULTS

The initial study population included 101,437 patients (41,753 children and 59,684 adults) from the commercially insured database and 33,793 patients (25,048 children and 8,745 adults) from the Medicaid database that met the study criteria. A demographic description of the study sample is provided in **Table 1**. Of the initial study population that met all the criteria, at least 45% of children and adults in the Medicaid population and at least 50% of children and adults in the commercially insured population were identified as being at risk for asthma exacerbation, depending on the assessment period. In the sample that was at risk for asthma exacerbation, the majority achieved a ratio of  $\geq 0.5$  (**Figure 1**). Adults were more likely than children to have a ratio of  $\geq 0.5$  in both the Medicaid and commercially insured populations. Similarly, a higher proportion of commercially insured patients (range 71% to 85%) had a ratio of  $\geq 0.5$  compared with Medicaid patients (range 58% to 73%).

### Receiver Operating Characteristic Curve Analysis

The AUCs predicted by the ratio ranged from 0.68 to 0.73 for children and 0.71 to 0.74 for adults (**Table 2**). The optimal ratio cutoffs within each assessment period (boldface entries in **Table 2**) were identified as those with the highest AUC values, and generally were at least  $\geq 0.5$  for both children and adults in both study populations. Statistical comparison of the AUCs then identified the optimal assessment

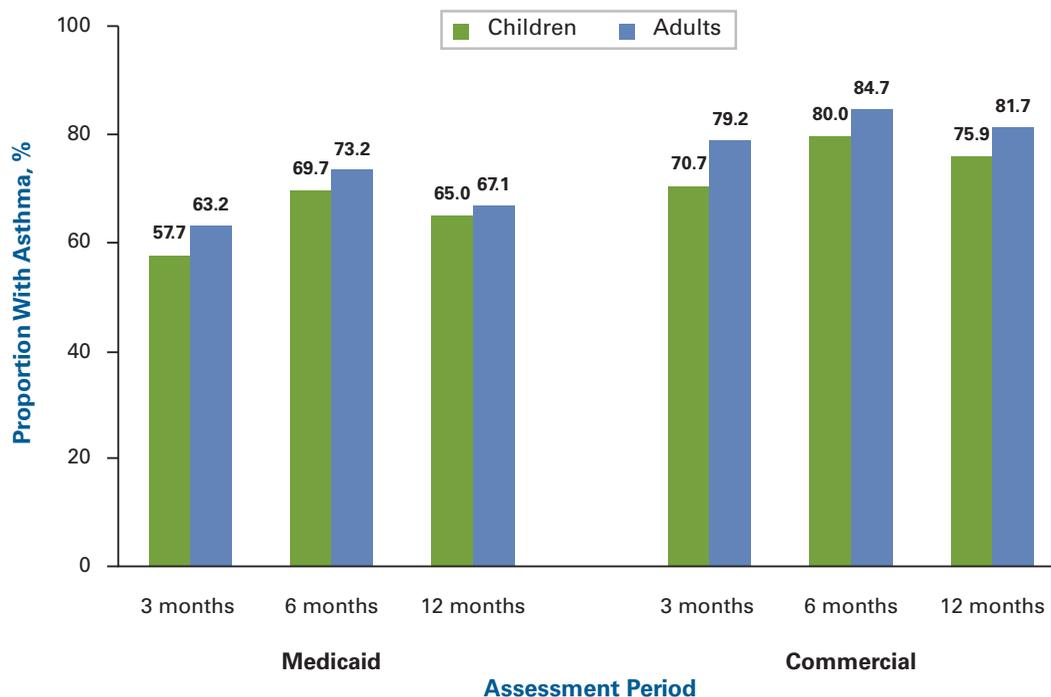
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■ **Table 1.** Baseline Characteristics of Study Sample

Characteristics	Medicaid		Commercial	
	Children (4-17 y) n = 25,048	Adults (≥18 y) n = 8745	Children (4-17 y) n = 41,753	Adults (≥18 y) n = 59,684
<b>Demographics</b>				
Age, y, mean (SD)	9.3 (3.9)	39.7 (16.2)	10.1 (4.0)	43.6 (13.3)
Male, n (%)	13,703 (54.7)	1654 (18.9)	23,414 (56.1)	21,473 (36.0)
<b>Clinical characteristics in preindex period</b>				
Charlson Comorbidity Index, mean (SD)	0.1 (0.4)	0.9 (1.5)	0.1 (0.3)	0.4 (1.0)
No. of unique diagnoses, mean (SD)	6.9 (4.5)	13.2 (8.4)	5.8 (4.1)	8.5 (6.8)
No. of prescription drug categories, mean (SD)	5.4 (3.2)	11.3 (6.7)	3.4 (2.0)	5.5 (3.8)
No. of prescriptions filled, mean (SD)	5.9 (3.8)	12.8 (8.2)	3.6 (2.2)	5.9 (4.2)
<b>Asthma severity in the assessment period</b>				
Presence of asthma-related hospitalization, n (%)				
3 months	131 (0.5)	67 (0.8)	168 (0.4)	324 (0.5)
6 months	183 (0.7)	85 (1.0)	212 (0.5)	396 (0.7)
12 months	271 (1.1)	115 (1.3)	286 (0.7)	548 (0.9)
Presence of asthma-related ED visit, n (%)				
3 months	1964 (7.8)	1177 (13.5)	1916 (4.6)	3284 (5.5)
6 months	2255 (9.0)	1287 (14.7)	2159 (5.2)	3531 (5.9)
12 months	2788 (11.1)	1483 (17.0)	2626 (6.3)	4081 (6.8)
<b>At-risk asthma population, n (%)</b>				
3 months	13,176 (52.6)	4603 (52.6)	23,099 (55.3)	36,292 (60.8)
6 months	11,310 (45.2)	4050 (46.3)	20,976 (50.2)	34,540 (57.9)
12 months	12,466 (49.8)	4391 (50.2)	22,688 (54.3)	36,198 (60.6)

SD indicates standard deviation.

■ **Figure 1.** Proportion of Children and Adults With Asthma Who Had Ratio Values of  $\geq 0.5$



**Table 2.** Area Under the ROC Curve for the Ratio Marker Cutoff Values for Each Assessment Period Predicting the Risk of Asthma Exacerbations in the 12-Month Follow-up Period<sup>a</sup>

Cutoff Value	Area Under the Curve					
	Children (4-17 y)			Adults (≥18 y)		
	3 months	6 months	12 months	3 months	6 months	12 months
<b>Medicaid</b>						
≥0.1	0.675	0.690	0.721	0.705	0.730	0.703
≥0.2	0.674	0.691	0.721	0.705	0.730	0.702
≥0.3	0.675	0.691	0.720	0.705	0.730	0.702
≥0.4	0.674	0.691	0.720	0.706	0.731	0.705
≥0.5	0.675	0.692	0.720	0.707	0.733	0.706
≥0.6	<b>0.683</b>	0.695	0.722	0.707	0.732	0.710
≥0.7	0.682	<b>0.700<sup>b</sup></b>	0.721	<b>0.711<sup>b</sup></b>	<b>0.738</b>	<b>0.718</b>
≥0.8	0.680	0.697	0.725	0.710	0.737	0.713
≥0.9	0.678	0.696	<b>0.729</b>	0.708	0.735	0.715
<b>Commercial</b>						
≥0.1	0.670	0.680	0.703	0.697	0.721	0.729
≥0.2	0.670	0.680	0.705	0.698	0.723	0.733
≥0.3	0.670	0.684	0.705	0.698	0.723	0.734
≥0.4	0.670	0.685	0.706	0.701	0.727	0.736
≥0.5	<b>0.673</b>	<b>0.690<sup>b</sup></b>	0.712	0.702	<b>0.731<sup>b</sup></b>	<b>0.741</b>
≥0.6	0.671	0.685	0.707	0.701	0.723	0.727
≥0.7	0.672	0.687	0.709	0.702	0.727	0.732
≥0.8	0.673	0.684	<b>0.714</b>	0.703	0.728	0.730
≥0.9	0.672	0.687	0.710	<b>0.704</b>	0.729	0.729

AUC indicates area under the curve; ROC, receiver operating characteristic.

<sup>a</sup>Asthma exacerbations included emergency department visits and inpatient hospitalizations.

<sup>b</sup>Indicates the AUC of the optimal cutoff value and corresponding assessment period.

Boldfaced values are the highest areas AUCs for each marker period.

period. For example, in the pediatric commercially insured population, a statistically significant difference between AUCs for the 3- and 12-month assessment periods ( $P = .005$ ) was found. The subsequent comparison between the 6- and 12-month AUCs was not significant ( $P = .114$ ); hence, 6 months was chosen as the optimal assessment period, with  $\geq 0.5$  designated as the optimal cutoff. Thus, in both children and adults at risk for asthma exacerbation, the ratio of  $\geq 0.5$  achieved during a 6-month assessment period was optimal in predicting an asthma exacerbation in the following year. In Medicaid patients, however, a higher optimal cutoff of  $\geq 0.7$  was found for both children and adults, but the optimal assessment period was shorter for adults (3 months) than for children (6 months).

An incremental effect on the risk of an exacerbation was observed for both children and adults in the commercially insured population, with the effect leveling after the optimal cutoff value of 0.5 (Figure 2A). However, each 0.1-unit increase in the ratio up to the optimal value of 0.5 resulted in

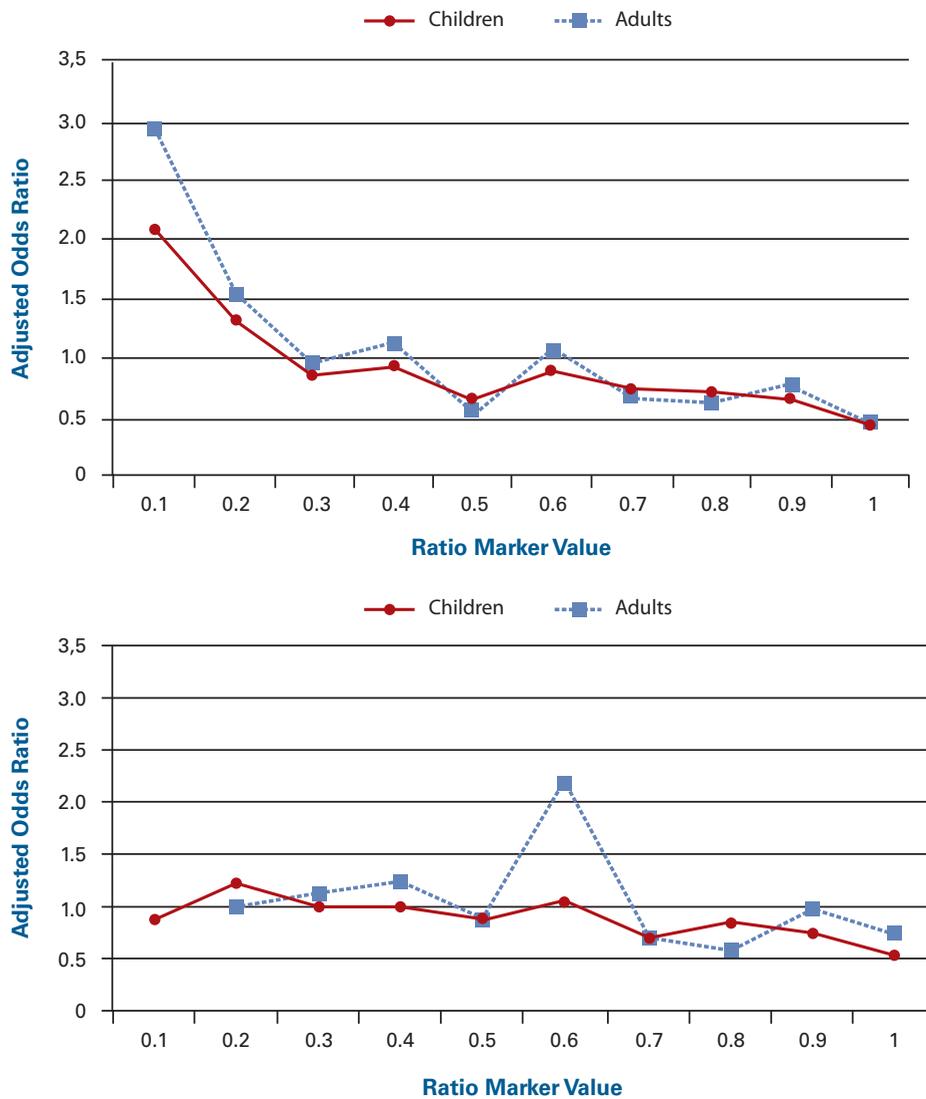
a significantly reduced risk of exacerbations in pediatric and adult commercially insured patients: 72% (OR 0.28; 95% CI 0.13-0.57) and 80% (OR 0.20; 95% CI 0.12-0.33), respectively. Similar to what happened in the commercially insured population, the risk reduction leveled off after the optimal cutoff of  $\geq 0.7$  for the Medicaid population (Figure 2B). However, each 0.1-unit increase in the ratio up to the optimal cutoff of 0.7 resulted in a significant reduction only for children (OR 0.65; 95% CI 0.43-0.97) and not adults.

### Predictive Ability of the Ratio for Outcomes

The optimal ratio significantly predicted reductions in the risk of exacerbations in the 12-month follow-up period in all cohorts. Pediatric Medicaid patients with a ratio of  $\geq 0.7$  in a 6-month assessment period and pediatric commercially insured patients with a ratio of  $\geq 0.5$  in a 6-month assessment period had a 31% (OR 0.69; 95% CI 0.59-0.81) and 33% (OR 0.67; 95% CI 0.56-0.80) lower risk of exacerbations, respectively, in the 12-month follow-up period compared with those who

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**Figure 2.** Adjusted Odds Ratios for Asthma Exacerbations by Incremental Changes in the Ratio Marker in Commercial (A) and Medicaid (B) Populations<sup>a</sup>



<sup>a</sup>Asthma exacerbations included emergency department visits or inpatient hospitalizations.

had lower ratios (Table 3). Adult Medicaid patients with a ratio of  $\geq 0.7$  in a 3-month assessment period and adult commercially insured patients with a ratio of  $\geq 0.5$  in a 6-month assessment period had a 31% (OR 0.69; 95% CI 0.55-0.86) and 48% (OR 0.52; 95% CI 0.45-0.60) lower risk of exacerbations, respectively, in the 12-month follow-up period compared with those who had lower ratios. The reduction in risk was primarily driven by the reduced risk of an ED visit. The ratio was not useful for predicting OCS-dispensing events in the Medicaid population. However, the ratio was associated with a reduction in OCS-dispensing events in the commercially insured cohort, with the difference being statistically significant only in adults (OR 0.81; 95% CI 0.76-0.88).

## DISCUSSION

The present study has provided valuable information on the optimal value of the controller-to-total medication ratio, as measured during defined time frames, for prediction of asthma events in patients receiving asthma pharmacotherapy. The ratio was found to be a significant predictor of subsequent exacerbations and OCS-dispensing events in both children and adults from databases containing Medicaid and commercially insured patients whom the study defined as being at risk for asthma exacerbation. The results are consistent with previous studies using HEDIS-defined persistent asthma populations in 12-month assessment periods,<sup>8,9,22</sup> even though this study defines a broader

■ **Table 3.** Relationships of Optimal Cutoffs of the Ratio Marker to Outcomes in the 12-Month Follow-up Period

Cohort	Optimal Cutoff and Assessment Period	OR (95% CI) <sup>a</sup>			
		Exacerbation (IP/ED Visit)	IP	ED Visit	OCS-Dispensing Event
<b>Medicaid</b>					
Children (n = 11,274 <sup>b</sup> )	≥0.7 in 6 months	0.69 (0.59-0.81) <sup>c</sup>	0.63 (0.41-0.96) <sup>c</sup>	0.71 (0.60-0.83) <sup>c</sup>	1.07 (0.97-1.17)
Adults (n = 4566 <sup>b</sup> )	≥0.7 in 3 months	0.69 (0.55-0.86) <sup>c</sup>	0.74 (0.40-1.35)	0.69 (0.55-0.87) <sup>c</sup>	1.11 (0.97-1.27)
<b>Commercial</b>					
Children (n = 20,892 <sup>b</sup> )	≥0.5 in 6 months	0.67 (0.56-0.80) <sup>c</sup>	0.86 (0.53-1.40)	0.66 (0.55-0.79) <sup>c</sup>	0.93 (0.85-1.02)
Adults (n = 34,188 <sup>b</sup> )	≥0.5 in 6 months	0.52 (0.45-0.60) <sup>c</sup>	0.57 (0.42-0.76) <sup>c</sup>	0.53 (0.46-0.62) <sup>c</sup>	0.81 (0.76-0.88) <sup>c</sup>

CI indicates confidence interval; ED, emergency department; IP, inpatient hospitalization; OCS, oral corticosteroid.

<sup>a</sup>Reference group is category below the cutoff.

<sup>b</sup>At-risk asthma patients with nonmissing ratio value.

<sup>c</sup>P < .05.

asthma subset that uses shorter measurement periods. However, use of the population at risk for asthma exacerbation broadens the applicability of the results to a wider asthma population.

A recent study showed a high concordance between ratio values computed using 6 months and 12 months of data in 94% of patients,<sup>7</sup> which is consistent with our finding that similar proportions of both child and adult patients had a value of ≥0.5 in the 6-month and 12-month assessment periods (Figure 1). However, to our knowledge, this study is the first to demonstrate that the ratio measured during an assessment period shorter than 12 months can still serve as a valid quality-of-care marker. The optimal cutoff values were found to be ≥0.7 in 6 months (Medicaid children), ≥0.7 in 3 months (Medicaid adults), ≥0.5 in 6 months (commercially insured children), and ≥0.5 in 6 months (commercially insured adults). This finding has important implications for monitoring asthma patients, in whom changes in therapy can be instituted much earlier with the goal of increasing the ratio.

Previous studies on the ratio in HEDIS-defined persistent asthma populations have shown the optimal cutoff to be ≥0.5.<sup>8,9,22</sup> The optimal cutoff value was reported as high as ≥0.9 in 1 study, but exacerbations were defined as emergency hospital care and OCS-dispensing combined, and significant risk reductions were noted at ≥0.4.<sup>10</sup> Unlike the commercially insured cohort, a higher optimal ratio of ≥0.7 was found for the Medicaid cohort in both children and adults. The reason for this higher value is not entirely clear, but may be related to the higher severity level or lower adherence of the Medicaid population (Table 1).

The optimal ratio values selected resulted in a 31% to 48% reduction in the risk of exacerbations in a 12-month follow-up period, which is within the range found in prior studies (23%-60%).<sup>5,8,10,26</sup> The optimal ratio values were less able to predict OCS-dispensing events, with a significant effect found only in the adult commercially insured population.

This study provides another valuable piece of information that helps to inform use of the medication ratio to monitor therapy: demonstration of an incremental risk reduction with 0.1-unit increases in the ratio. This finding helps patients and caregivers by showing that increasing the medication ratio is valuable, even before the ultimate goal (optimal ratio) is achieved. From a managed care standpoint, it may allow for cost-benefit analyses of performance measures to determine optimal treatment strategies.

### Limitations

Several study limitations need to be considered. The study-defined population at risk for asthma exacerbation was not validated using clinical criteria. As such, we cannot exclude the possibility that intermittent asthma patients were included. However, at least 75% of the patients at risk for asthma exacerbation had a nonzero value for the ratio (Figure 2), suggesting a low proportion of patients with intermittent asthma. Increasing the number of controller medications or reducing SABA use will increase the ratio. The manner in which the ratio is increased cannot be determined from the study, but rather would depend on the treatment requirements of the individual patient. However, considering that controller medications are preventive treatment for symptoms, the increased use of controllers should reduce the need for albuterol. Prescription claims were used and a prescription that was filled was assumed to be taken. That may not be the case for drugs used on an as-needed basis (eg, SABAs). In addition, the possibility of miscoding or undercoding of diagnoses on claims may have resulted in underestimation of the prevalence of the main outcome of hospital and ED visits. However, this underestimation, if any, would be similar across comparison groups.

### CONCLUSIONS

This study has shown that the ratio performs as a significant predictive risk marker in at-risk commercially insured

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and Medicaid asthma populations during a period shorter than 12 months. Furthermore, incremental reductions in risk can be realized by increasing the value of the ratio. It is hoped that this quality-of-care marker can be used to identify higher-risk patients in a timely manner so that targeted interventions can reduce their risk of future exacerbations. However, further studies will be necessary to demonstrate this effect.

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**Authorship Information:** Concept and design (RHS, MBS, AOD, MS); acquisition of data (RHS); analysis and interpretation of data (RHS, MBS, AOD, MS); drafting of the manuscript (RHS, AOD); critical revision of the manuscript for important intellectual content (RHS, MBS, AOD, MS); statistical analysis (MBS, AOD); obtaining funding (RHS); administrative, technical, or logistic support (RHS, AOD); and supervision (RHS).

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