# A Longitudinal Examination of the Asthma Medication Ratio in Children

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## ABSTRACT

**OBJECTIVES:** The asthma medication ratio (AMR) (number of controller medications / [number of controller medications + number of rescue medications]) can be calculated using claims data. This measure has not previously been studied longitudinally. Our objective is to conduct a longitudinal examination of the AMR in a large national cohort of children with asthma.

**STUDY DESIGN:** Retrospective analysis of pharmacy and medical claims data.

**METHODS:** Using 2013-2014 TruvenHealth MarketScan data, we identified children with asthma. Beginning with the month of first controller claim, we calculated an AMR for each rolling 3-month period and each rolling 6-month period and examined the proportion who had AMRs classified as low-risk (≥0.5), high-risk (<0.5), and missing for each period. Using logistic regression, we tested how a rolling AMR predicted a child's hospitalization or emergency department (ED) visit for asthma.

**RESULTS:** We identified 197,316 patients aged 2 to 17 years with a claim for a controller. AMRs were relatively stable over time, with the majority of patients remaining in the same AMR category through a 12-month period. Using both the rolling 3-month and 6-month AMRs, a higher proportion of patients with high-risk AMRs (9.6% and 9.5%, respectively) had an ED visit or hospitalization compared with patients with low-risk (5.0% and 5.7%) and missing (3.5% and 3.2%) AMRs ($P$ <.0001). Using logistic regression, the 3-month AMR is more strongly associated with subsequent ED visit or hospitalization than the 6-month AMR.

**CONCLUSIONS:** AMR-based risk assignment is relatively stable over time. Three-month AMR calculation periods appear to provide the most accurate assessment of risk. Children with missing AMRs likely have inactive asthma and are at the lowest risk for emergent asthma visits.


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Asthma remains a frequent cause of emergency department (ED) visits and hospitalizations among children.[1] Controller medications, particularly inhaled corticosteroids (ICSs), are effective at reducing the incidence of these acute care visits for asthma.[2-4] However, these medications continue to be underutilized.[5-8] Using pharmacy claims data to identify patterns of poor controller medication adherence is a potential way to target medication adherence interventions to high-risk children. With this in mind, the asthma medication ratio (AMR; number of controller medication claims / [number of controller medication claims + number of rescue medication claims]) has been developed to measure adherence and assign risk for exacerbation.[9-16] Findings from previous studies have shown that the AMR predicts risk for future exacerbation on the patient level.[10-12,17] The AMR has the potential to risk stratify large populations of children with asthma in real time, thereby accurately identifying the patients at highest risk for exacerbation and allowing for intervention before exacerbation occurs. This could ultimately prevent costly ED visits and hospitalizations, driving down healthcare costs and improving quality of life attributed to this common pediatric chronic disease.

Despite its potential for risk assessment and risk communication to prevent exacerbations, the AMR has not yet been translated to a point-of-care, real-time monitoring tool. All previous AMR studies have utilized a fixed cross-sectional AMR assessment period, capturing adherence behaviors for 1 specific moment. Before designing and testing an AMR-based intervention, we must better understand the longitudinal behavior of the AMR using rolling periods. This represents the most practical way to calculate the AMR in real time and will allow risk assessment using the most recent claims data available.

Traditionally, studies have relied on the Healthcare Effectiveness Data and Information Set (HEDIS) criteria for persistent asthma to determine who is eligible for AMR measurement. HEDIS is a quality tool and was designed to measure systems, not individuals. HEDIS criteria work well for reporting on the performance of health

systems through tools such as the Quality Compass. Previous studies' results have shown that patients often do not meet HEDIS criteria for persistent asthma in consecutive years and that the number of consecutive years of HEDIS qualification was strongly associated with ICS use.[18] HEDIS requires up to 1 year of claims monitoring in order to classify a patient as persistent asthmatic. This would lead to missed opportunities for intervention during the measurement year and potential inappropriate interventions the following year. Instead, we propose that the AMR can be measured in all children with a pharmacy claim for an ICS. According to the National Heart, Lung, and Blood Institute (NHLBI) Guidelines for the Diagnosis and Management of Asthma, ICSs are recommended only for children with persistent asthma.[19] Therefore, it is unlikely that children with intermittent asthma would be identified using this criterion.

**TAKEAWAY POINTS**

The asthma medication ratio (AMR) can be calculated using pharmacy claims data and used to identify patients with asthma who are at highest risk for exacerbation in the coming months.

- AMR-based risk assignment is relatively stable over time.
- In any given time period, 5% to 8% of children with asthma will be at high risk.
- Children with no pharmacy claims for either rescue or controller medications are at lowest risk for exacerbation.

The objective of this study was to examine the longitudinal behavior of the AMR among a large national cohort of privately insured children with asthma, including a comparison of the predictive accuracy of a 3-month rolling AMR with that of a 6-month rolling AMR, as well as determining the proportion of patients in each risk category at any given time.

# METHODS

## Study Cohort

In order to identify all children for whom the AMR would be a potentially valid risk assessment tool, we first identified all asthma medication claims from the Truven Health MarketScan pharmacy claims databases for 2013 and 2014 using National Drug Code numbers. Medications were then categorized as rescue medications or controller medications. Patients aged 2 to 17 years with any claim for an ICS-containing medication were eligible for inclusion in our study cohort. Because we took an alternative approach to identifying the cohort of children eligible for AMR measurement, we assessed the proportion of our cohort that met HEDIS persistent asthma criteria and determined in any given AMR measurement period how many patients would qualify as at high risk for exacerbation but not as persistent asthmatic according to HEDIS criteria.

We defined each patient's study index date as the date of his or her first ICS-containing medication claim in the study period. Patients with fewer than 360 ($12 \times 30$) days of continuous insurance enrollment after their index date and patients with a diagnosis of cystic fibrosis (*International Classification of Diseases, Ninth Revision* [*ICD-9*] code 277.XX) at any time during the study period were excluded. We then identified all inpatient and ED visit claims with a primary diagnosis of asthma (*ICD-9* code 493.XX) for each patient in the cohort. Only those claims representing visits that occurred after the patient's index date were retained in the final analytical data set. Covariates used in this analysis include patient age (defined as age at index date, operationalized continuously and in age categories), sex, geographic region, and season of index date (winter, January-March; spring, April-June; summer, July-September; fall, October-December). MarketScan does not include a race variable.

## Ratio Calculation

Using the formula of number of controller medication claims/(number of controller medication claims + number of rescue medication claims), an AMR was calculated for each patient in each month from the index date to study month 12. AMRs can range from 0 (only rescue medication claims) to 1 (only controller medication claims) or be "missing" (no rescue or controller medication claims) for any given period. Leukotriene-receptor modifiers were included as controllers in the AMR calculation if there was not also an ICS-containing medication claim that month, but they were not included as index controllers. This decision was made to ensure that our cohort represented children with persistent asthma who received first-line guideline-recommended therapy for that diagnosis. Oral albuterol was not included as a rescue medication.

Similar to previous studies, we first calculated fixed 12-month, 6-month, and 3-month AMRs for each patient for the 12 months after the index date. Therefore, each patient has one 12-month AMR, 2 fixed 6-month AMRs, and 4 fixed 3-month AMRs. Next, we calculated rolling AMRs for each patient. Rolling 3-month AMRs were calculated using months 1 to 3, 2 to 4, 3 to 5, and so on. Rolling 6-month AMRs were calculated using months 1 to 6, 2 to 7, 3 to 8, and so on.

Based on previous study results, AMRs were classified as high-risk ($<0.5$), low-risk ($\geq 0.5$), or missing for each calculation period. Because of our definition of index date, the AMR values for the first period (those that include month 1) are artificially inflated. Identifying this phenomenon influenced further analytical decisions.

Population-level AMR distribution through 12 study months was plotted using stacked bar charts. Patients in each category (high-risk, low-risk, and missing) for the first analyzable rolling 6-month and 3-month period were tracked at the population level over the course of the year. We also determined the proportion of patients who remained in the same risk category from one month to the next.

## METHODS

**TABLE 1.** Demographics of Children in the Truven MarketScan Commercial Database With at Least 1 ICS-Containing Medication Claim in 2014-2015 (N = 197,316)

| Characteristic | Value |
|---|---|
| Age, years, mean/median (range) | 8.8/8 (2-17) |
| Age category, years, n (%) | |
| 2-6 | 70,551 (36%) |
| 7-12 | 80,503 (41%) |
| 13-17 | 46,262 (23%) |
| Sex, n (%) | |
| Male | 118,266 (60%) |
| Female | 79,050 (40%) |
| Geographic region, n (%) | |
| Northeast | 43,889 (22%) |
| North Central | 41,603 (21%) |
| South | 69,775 (35%) |
| West | 35,792 (18%) |
| Unknown | 6257 (3%) |
| Index controller category,[a] n (%) | |
| ICS | 163,185 (83%) |
| ICS/LABA | 34,131 (17%) |
| Index controller season,[b] n (%) | |
| Winter (Jan-Mar) | 93,374 (47%) |
| Spring (Apr-Jun) | 41,947 (21%) |
| Summer (Jul-Sep) | 28,349 (14%) |
| Fall (Oct-Dec) | 33,646 (17%) |
| Proportion with any event[c] within, n (%) | |
| 3 months of index date | 2800 (1.4%) |
| 6 months of index date | 4368 (2.2%) |
| 9 months of index date | 5955 (3.0%) |
| 12 months of index date | 7604 (3.9%) |
| 15 months of index date | 8825 (4.5%) |

ED indicates emergency department; *ICD-9*, *International Classification of Diseases, Ninth Revision*; ICS, inhaled corticosteroid; LABA, long-acting β agonist.
[a]Index controller is defined as the first ICS or ICS/LABA claim within the study period.
[b]Index controller season is the season of the index controller claim, making it the season of the patient's index date as well.
[c]Any ED visit or hospitalization with a primary diagnosis of asthma (*ICD-9* code 493.XX).

### Subgroup Analysis

To identify differences by patient characteristics, AMR classification changes over time were also assessed by age group, season of index date, and category of index controller (ICS vs ICS/long-acting β agonist [LABA]).

### Outcome Definition

ED visits and hospitalizations with a primary diagnosis of asthma (*ICD-9* code 493.XX) were identified. Having any ED visit or hospitalization for asthma in a given period was the primary dichotomous outcome for this study. Future studies should include more in-depth analyses of the rolling AMR's relationship to this outcome as well as individual outcomes of ED visits, hospitalizations, and oral steroid dispensing events.

### Preliminary Outcome Analysis

To begin to understand how patients with missing AMRs should be classified in future interventional studies, we compared proportions of patients with any ED visit or hospitalization for asthma among those classified as having high-risk, low-risk, and missing AMRs in the first analyzable rolling 3-month and 6-month periods (months 2-4 and months 2-7, respectively). Chi-square tests were used to identify any statistically significant differences.

### Determining the Relative Strength of Association of 3-Month Versus 6-Month Rolling AMRs With Events

Simple logistic regression models with the outcome of ED visit or hospitalization in 3-month and 6-month outcome windows were built for rolling 3-month AMRs and rolling 6-month AMRs. Comparisons of odds ratios (ORs) between the 3-month AMRs and 6-month AMRs were used to quantify strength of association to help inform the decision of which calculation strategy to use in subsequent analyses.

## RESULTS

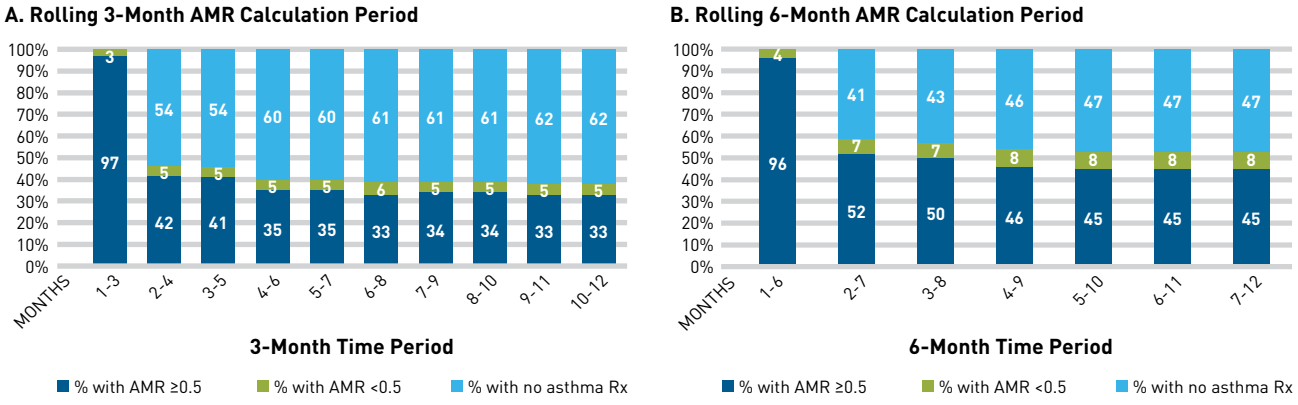
### Demographics

Of the 9.5 million children aged 2 to 17 years present in the 2013 MarketScan data, 197,316 patients had least 1 claim for an ICS or ICS/LABA and at least 360 days of continuous enrollment after their index date. Of these patients, 60% were male and the mean age was 8.8 years; 36% were aged 2 to 6 years, 41% aged 7 to 12, and 23% aged 13 to 17. Forty-seven percent of assigned index dates were in the winter (January-March). Eighty-three percent of children had an ICS as their index controller. Ultimately, 4.5% of patients had at least 1 ED visit or hospitalization with a primary diagnosis of asthma within 18 months of their study index date (**Table 1**).

### HEDIS Categorization of Patients in Cohort

Forty-two percent of the patients in our cohort qualified as persistent asthmatic using the HEDIS criteria. The majority of the 58% who would not qualify as such under HEDIS criteria ("non-HEDIS") are represented in the missing AMR category in any given AMR measurement period. For example, in months 2 to 4, 85,152 of the 114,320 non-HEDIS patients had a missing AMR; 26,569 had a low-risk AMR; and 2599 had a high-risk AMR (**eAppendix Figure 1** [eAppendix available at **ajmc.com**]).

**FIGURE 1.** AMR Classification Through 12 Months for a Cohort of 197,316 Privately Insured Children With Asthma




AMR indicates asthma medication ratio; Rx, prescription.

## Rolling 3-Month Versus Rolling 6-Month AMR

Using a rolling 3-month AMR calculation period and excluding the month 1 values due to the issue of AMR inflation, an average of 5% of the cohort were identified as high-risk in each calculation period, while 59% had a missing AMR (no asthma prescriptions filled during the calculation period) (**Figure 1A**). Using a rolling 6-month AMR calculation period and excluding the month 1 values, an average of 8% of the population were identified as high-risk in each calculation period and an average of 45% had a missing AMR (**Figure 1B**). Moving from a 3- to a 6-month calculation period significantly reduced the proportion of patients with missing AMRs in each given AMR calculation period. In regression analysis with the outcome variable of any ED visit or hospitalization for asthma, the 3-month AMRs had a stronger predictive ability than the 6-month AMRs (OR for 3-month AMR in months 2-4 with 3-month outcome window, 2.5; 95% CI, 2.1-2.9; OR for 6-month AMR in months 2-7 with 3-month outcome window, 1.8; 95% CI, 1.6-2.1). **Table 2** presents complete results through the entire study period.

## AMR Inflation

The issue of AMR inflation with our index date assignment is demonstrated graphically (**eAppendix Figure 2**). Because time is not accounted for in the AMR, even 1 month with a controller fill can significantly inflate a patient's AMR for the following 11 months.

## Subgroup Analysis

There was a slightly higher proportion of children 13 years and older in the high-risk AMR category compared with younger children (**eAppendix Figure 3**). A higher proportion of children with a winter index date maintained low-risk AMRs throughout the year (**eAppendix Figure 4**). Children whose index controller was an ICS/LABA rather than an ICS were more likely to have a low-risk AMR throughout the year, indicating better adherence to controller medication therapy (**eAppendix Figure 5**).

**TABLE 2.** Odds of an Asthma-Related ED Visit or Hospitalization for a Child With an AMR <0.5 Using 3-Month and 6-Month Rolling Calculation Periods

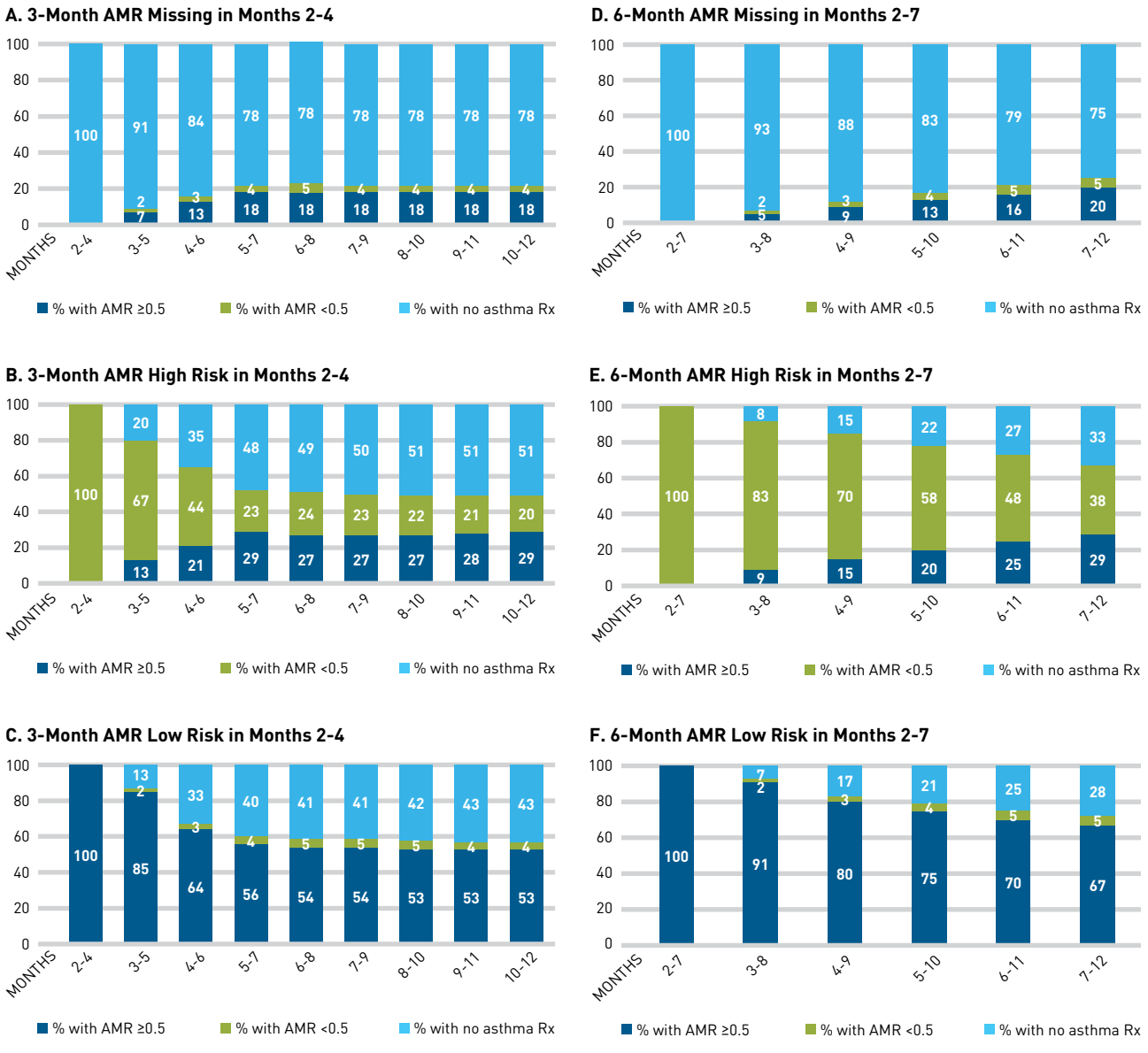
| | 3-Month Outcome Period[a] OR (95% CI) | 6-Month Outcome Period[a] OR (95% CI) |
|---|---|---|
| **Rolling 3-Month AMRs** | | |
| Months 2-4 | 2.5 (2.1-2.9) | 2.2 (2.0-2.5) |
| Months 3-5 | 2.3 (2.0-2.7) | 2.0 (1.8-2.3) |
| Months 4-6 | 2.0 (1.7-2.3) | 1.9 (1.7-2.1) |
| Months 5-7 | 1.8 (1.5-2.1) | 1.8 (1.6-2.0) |
| Months 6-8 | 1.7 (1.5-2.0) | 1.7 (1.5-1.9) |
| Months 7-9 | 1.7 (1.5-2.0) | 1.7 (1.5-1.9) |
| Months 8-10 | 1.8 (1.5-2.1) | 1.8 (1.6-2.0) |
| Months 9-11 | 2.0 (1.8-2.4) | 1.9 (1.7-2.1) |
| Months 10-12 | 1.9 (1.6-2.2) | 1.7 (1.5-2.0) |
| **Rolling 6-Month AMRs** | | |
| Months 2-7 | 1.8 (1.6-2.1) | 1.9 (1.7-2.0) |
| Months 3-8 | 1.8 (1.6-2.1) | 1.8 (1.7-2.0) |
| Months 4-9 | 1.7 (1.5-1.9) | 1.7 (1.5-1.8) |
| Months 5-10 | 1.7 (1.5-1.9) | 1.6 (1.5-1.8) |
| Months 6-11 | 1.8 (1.6-2.1) | 1.7 (1.5-1.8) |
| Months 7-12 | 1.6 (1.4-1.8) | 1.5 (1.4-1.7) |

AMR indicates asthma medication ratio; ED, emergency department; OR, odds ratio.
[a]Each outcome period begins the month following the last month of the AMR calculation period.

## Do Children Stay in the Same Category Throughout the Year?

To determine if early risk-category assignment held throughout the year or if children frequently bounced in and out of categories, we followed children in each group (low-risk, high-risk, and missing,

**FIGURE 2.** AMR Classification Stability Through 12 Months in a Cohort of Privately Insured Children With Asthma




AMR indicates asthma medication ratio; Rx, prescription.

based on their assignment in the first analyzable period) through the year. The majority of children with a missing AMR in the first analyzable period continued to have missing AMRs through month 12. Similarly, the majority who were initially low-risk remained low-risk through month 12. The biggest departures from original classification occurred in the high-risk group, with only 20% (in the 3-month approach) and 39% (in the 6-month approach) remaining high-risk through month 12 (**Figure 2A-F**). Analyzed another way, of patients who had a high-risk AMR in any given calculation period, an average of 68% had a high-risk AMR in the following calculation period. Of patients with a low-risk AMR in any given period, an average of 84% had a low-risk AMR in the following calculation period. Finally, of patients with a missing AMR in any given period, an average of 90% had a missing AMR in the following calculation period.

## How to Handle Missing AMRs

With such a large proportion of the population having missing AMRs, it was important to begin to understand how to handle these patients. The fact that they had no albuterol claims suggests

that they are at low risk for exacerbation, but could they actually be at high risk and either using albuterol from previous months or not recognizing their symptoms? To help answer this question, we used each patient's classification from the first analyzable period and calculated the proportion of patients in each category with any emergent event in study months 1 through 18. The patients with missing AMRs had the lowest proportion of events in both approaches (3.5% based on 3-month AMR classification and 3.2% based on 6-month AMR classification). This was significantly lower than the proportion with events in both the high-risk and low-risk AMR categories ($P$ <.0001). This finding suggests that those children with missing AMRs are likely to be children with inactive asthma at low risk for exacerbation (**Table 3**).

**TABLE 3.** Population-Level Frequency of Emergent Events by AMR Category in Months 2-7 (rolling 6 month) and Months 2-4 (rolling 3 month)

| Months 2-7 AMR (rolling 6-month AMR) | n | Proportion With Any Event Between Index Date and Study Month 18 | *P* |
|---|---|---|---|
| Missing | 80,921 | 3.2% | |
| ≥0.5 (low risk) | 102,874 | 5.7% | <.0001 |
| <0.5 (high risk) | 13,521 | 9.5% | |
| **Months 2-4 AMR (rolling 3-month AMR)** | **n** | **Proportion With Any Event Between Index Date and Study Month 15** | ***P*** |
| Missing | 103,655 | 3.5% | |
| ≥0.5 (low risk) | 84,481 | 5.0% | <.0001 |
| <0.5 (high risk) | 9180 | 9.6% | |

AMR indicates asthma medication ratio.

# DISCUSSION

This longitudinal analysis of the AMR in a large cohort of privately insured children with asthma supports the rolling AMR calculation as a practical approach to risk assessment. This approach is superior to a cross-sectional fixed-AMR calculation period approach as it allows for risk category assignment based on the most recent available claims data. When applied to this cohort of privately insured children with asthma, the rolling 3-month calculation approach identified approximately 5% of the population as being at high risk for exacerbation in any given period.

As the AMR calculation period decreases (from 12 to 6 to 3 months), a larger proportion of patients have missing AMRs in any given period. To have a missing AMR, the patient must not have any claims for rescue or controller medications in the AMR calculation period. The higher proportion of patients with missing AMRs in the 3-month approach suggests that the 6-month AMR calculation approach might be superior to the 3-month approach. However, further investigation supports the 3-month approach. First, we demonstrated that children with missing AMRs are less likely to have an ED visit or hospitalization for asthma compared with children with both low-risk and high-risk AMRs. These children appear to have relatively inactive asthma, illustrated by their absence of asthma medication claims and low rate of emergent care visits. This raises the idea that some children do not necessarily remain persistent asthmatics for long periods, reflecting variation in their asthma control. They may require controller medications most of the time, but they may also have periods of disease inactivity where they do fine without controller medications. Recognizing these patients clinically will be a challenge, however. We suggest that children with missing AMRs can be treated like children with low-risk AMRs in future interventional studies. Second, our regression analysis illustrates that the 3-month AMR has a stronger relationship to the outcome of ED visit or hospitalization for asthma compared with the 6-month AMR. However, both are statistically significant, suggesting that a 6-month AMR approach would be valid and acceptable.

Differences in adherence patterns between patients with ICS versus those with ICS/LABA raise the question of whether or not these 2 populations can be handled the same way in an AMR-based intervention study. There are several potential reasons that the latter group has better controller medication adherence than the ICS group. The NHLBI Guidelines for the Diagnosis and Management of Asthma recommend subspecialist consultation for any child requiring "Step 4" therapy, which includes ICS/LABAs.[19] Therefore, these children are likely to have more severe baseline disease and to have been seen by a subspecialist than are children on ICS therapy alone. The cumulative medication adherence messaging that ICS/LABA patients receive might be more extensive and more effective than the messaging that ICS patients receive.

Because of our method of index date assignment, our study highlights the issue of AMR inflation. In a rolling approach with shorter AMR calculation periods, an initial month with a controller claim would be dropped as soon as the next month's claims data are available, allowing for a more accurate AMR-based risk assessment. There is less potential for inflation with shorter rolling calculation periods.

## Limitations

This study has several limitations. First, we used administrative claims data for this analysis. Claims data lack the clinical detail that might be found in other data sources, such as electronic health records. However, claims data remain the most accurate source for determining medication adherence patterns in large populations of patients. Our method of cohort identification is novel; therefore, our findings cannot be directly compared with those of previous AMR studies that have used HEDIS criteria for cohort identification. As outlined above, we feel that the presence of an ICS claim in the

absence of a cystic fibrosis diagnosis will identify an appropriate cohort of children with asthma who could potentially benefit from AMR monitoring in addition to monitoring of the National Quality Forum Medication Management for People with Asthma measure of the percentage of persistent asthmatics who were dispensed an asthma controller medication that they remained on for at least 75% of their treatment period.[20] As with all research that utilizes administrative claims data, we do not know what happened before the first day in our database. It is likely that many of the children who were assigned an index date in January 2013 (the first month of our data) had controller claims well before that date. This may have affected our subgroup analysis by season. Unfortunately, there is no way to mitigate this challenge of working with administrative claims data. We do not feel that this issue significantly impacts our primary findings. We were not able to determine prescription writing patterns from these data; therefore, we do not know to what degree a patient's filling behavior contributes to controller medication nonadherence. Prescriptions that are not paid by the insurance company (ie, free samples or those paid out-of-pocket by the caregiver) would not be included in these data. We are unable to generalize our findings to publicly insured populations, as this analysis was limited to privately insured patients. Finally, the MarketScan database does not include a race or ethnicity variable; therefore, we are unable to determine differences in AMR patterns by race or ethnicity.

## CONCLUSIONS

In this longitudinal examination of the AMR in a large cohort of privately insured children with asthma, we determined that the rolling 3-month AMR approach will identify approximately 5% of children as high-risk in any given period. Patients with no asthma medication claims in any given AMR calculation period appear to be at low risk for exacerbation, suggesting that their asthma is inactive. These findings lay the groundwork for future asthma medication adherence interventional studies utilizing real-time monitoring of pharmacy dispensing data embedded within the electronic health record. ■

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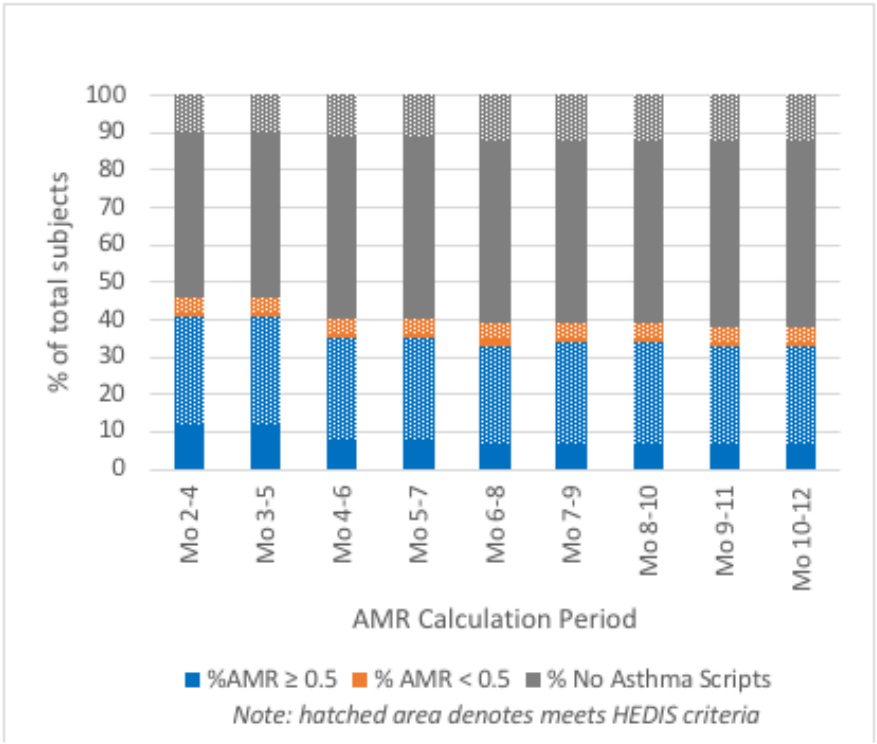
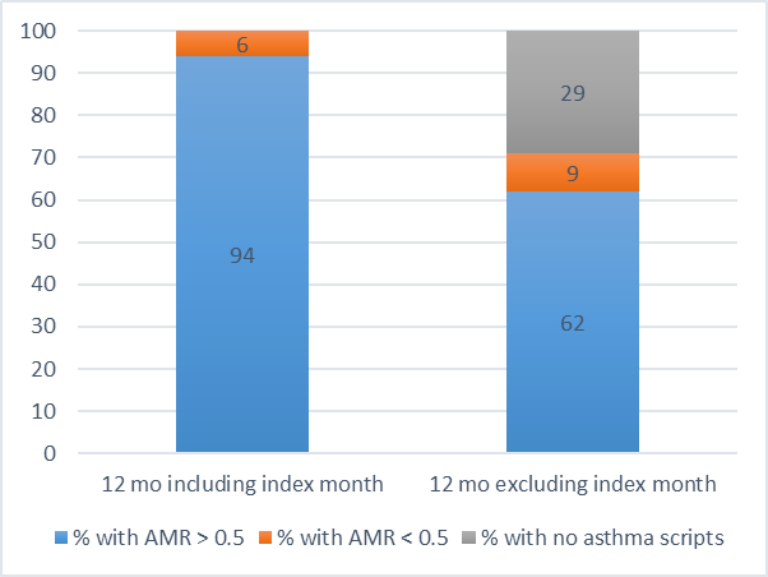
**eAppendix Figure 1.** Proportion of Cohort Meeting HEDIS Criteria for Persistent Asthma, by AMR Category




AMR indicates asthma medication ratio; HEDIS, Healthcare Effectiveness Data and Information Set.

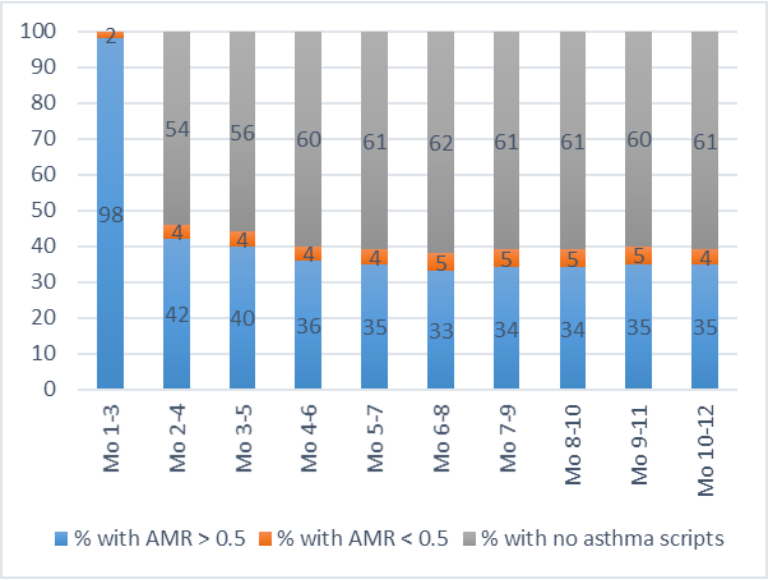
**eAppendix Figure 2.** 12-Month AMR Including Index Month vs Excluding Index Month for a Cohort of 197,316 Privately Insured Children With Asthma



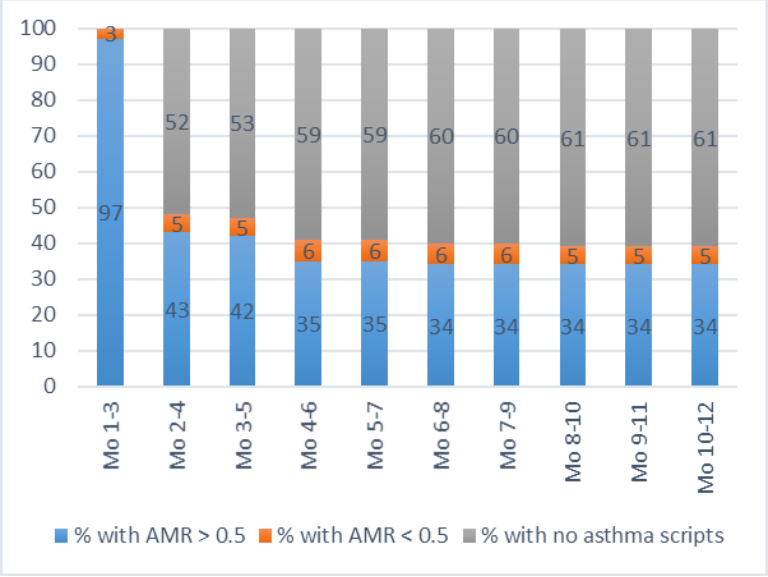

AMR indicates asthma medication ratio.

**eAppendix Figure 3.** AMR Classification Through 12 Months for a Cohort of 197,316 Privately Insured Children With Asthma by Age Group

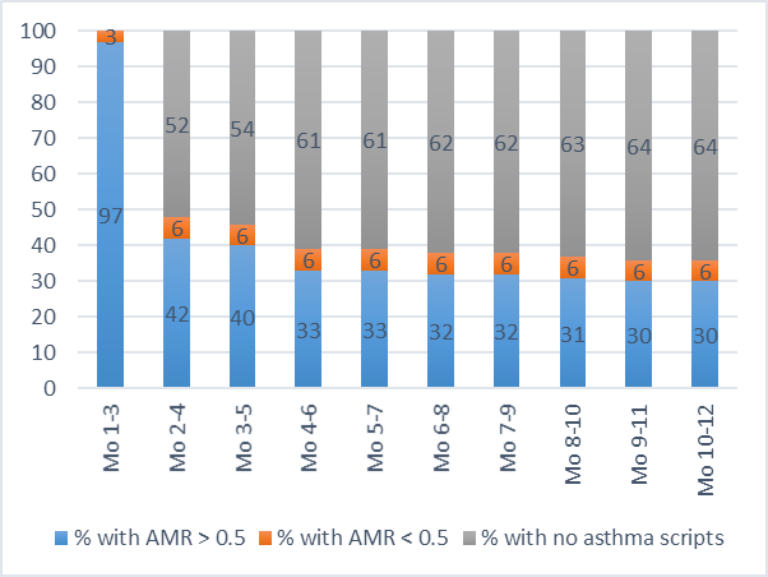
**A.** Aged 2-6 Years: Rolling 3-Month AMR Calculation Period




**B.** Aged 7-12 Years: Rolling 3-Month AMR Calculation Period



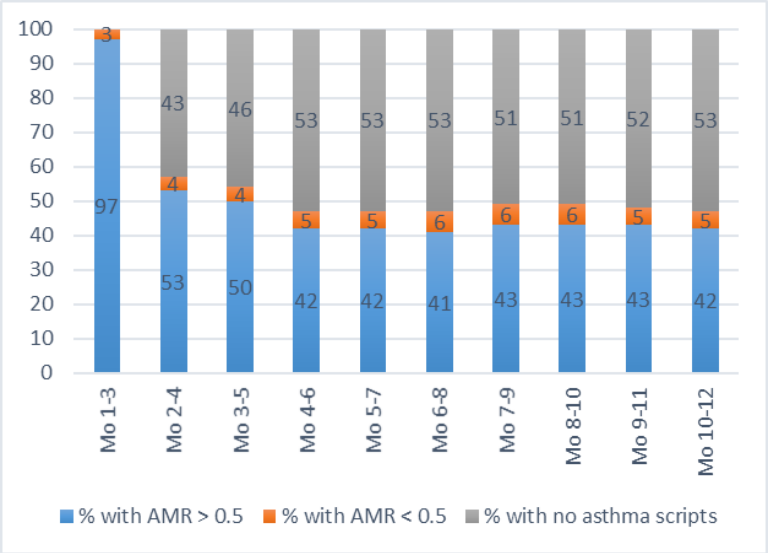
**C.** Aged 13-17 Years: Rolling 3-Month AMR Calculation Period



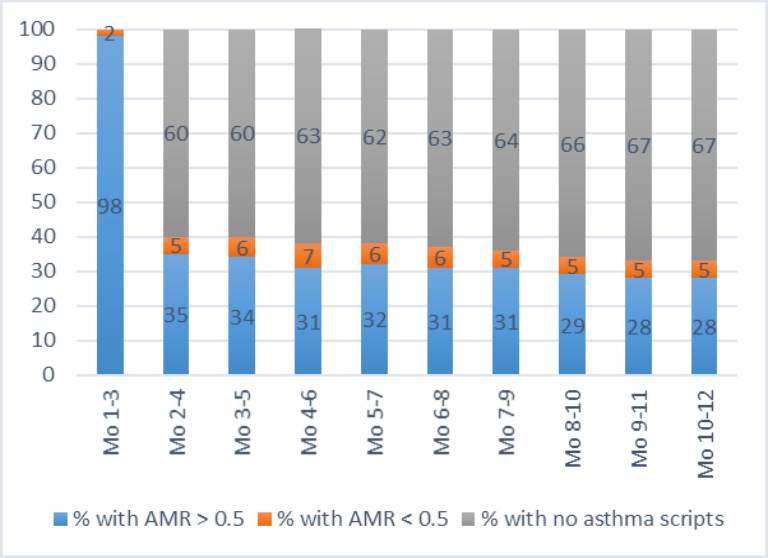

AMR indicates asthma medication ratio.

**eAppendix Figure 4.** Rolling 3-Month Asthma Medication Ratio by Season of Index Date

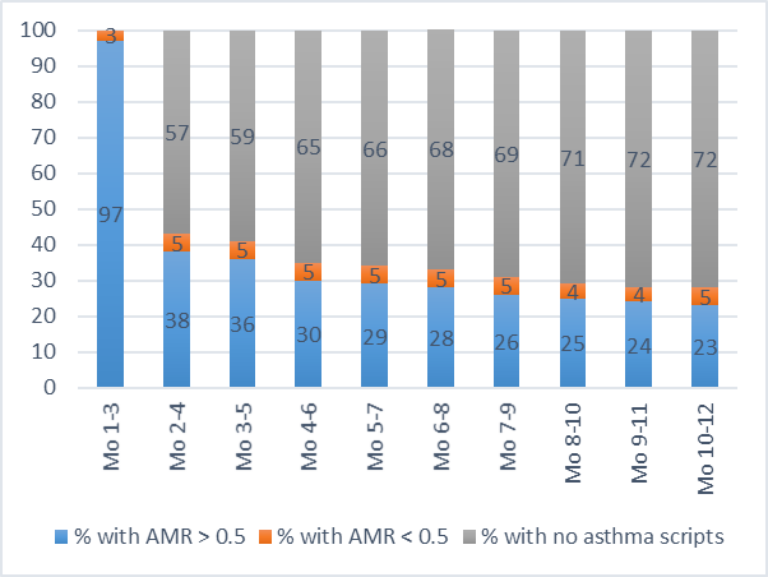
**A.** Winter Index Date



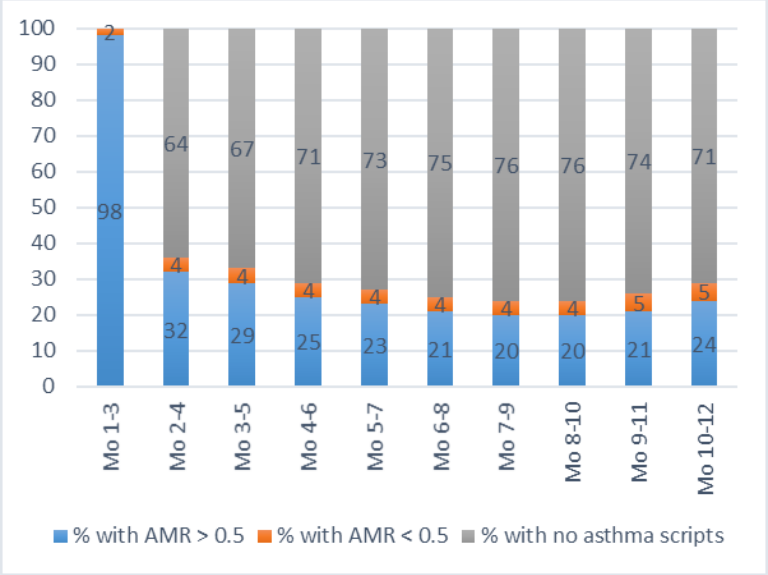

**B.** Spring Index Date



**C.** Summer Index Date



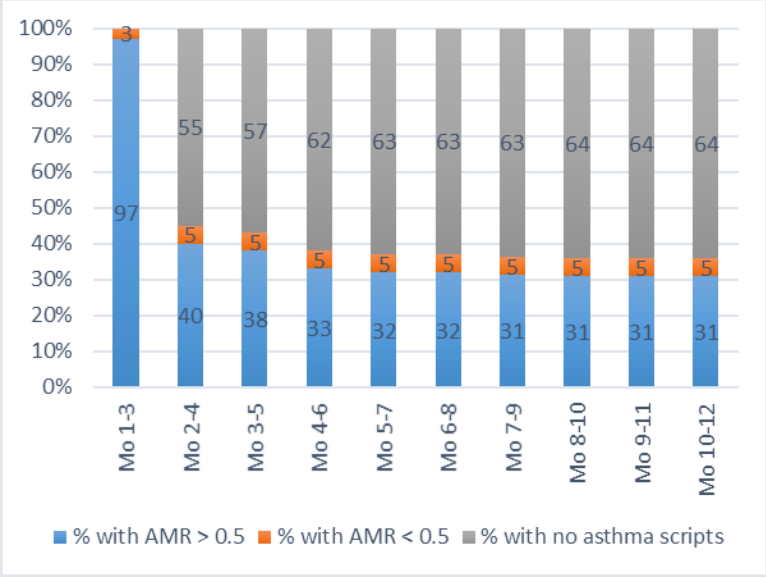

**D.** Fall Index Date



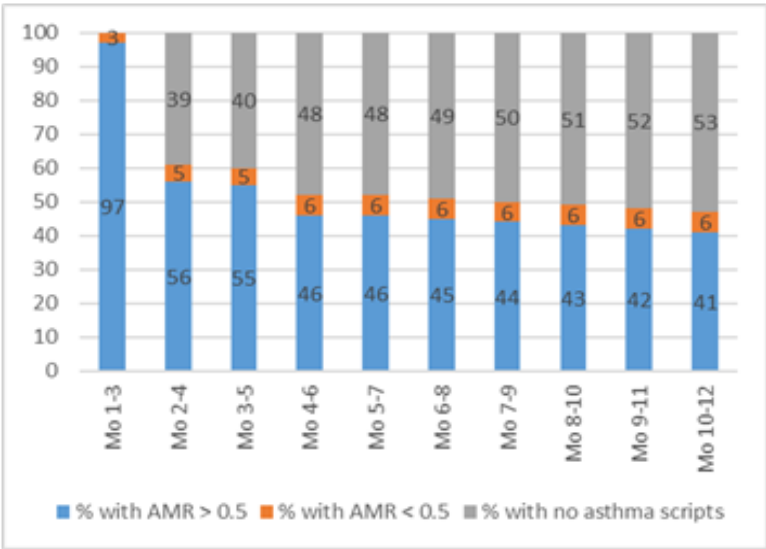

AMR indicates asthma medication ratio.

**eAppendix Figure 5.** AMR Classification Through 12 Months for a Cohort of 197,316 Privately Insured Children With Asthma: Comparison of Patients With ICS vs ICS/LABA

**A.** Patients With ICS as Index Controller




**B.** Patients With ICS/LABA as Index Controller




AMR indicates asthma medication ratio; ICS, inhaled corticosteroid; LABA, long-acting β agonist.