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A Longitudinal Examination of the Asthma Medication Ratio in Children with Medicaid

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Abstract

Background/Objective: An efficient and accurate strategy for identifying children with asthma at high risk exacerbation is needed. The objective of this study is to conduct a longitudinal examination of the asthma medication ratio (AMR) (#of controller medication claims/(# of controller medication claims + # of rescue medication claims)) in Medicaid-funded children with asthma. This measure has the potential to be a near real-time risk assessment tool.

Study Design: We conducted a retrospective analysis of 2013-2014 TruvenHealth Medicaid data. We analyzed pharmacy and medical claims for a cohort of children with asthma. We identified patients age 2-17 yrs with at least one claim for an inhaled corticosteroid. We calculated an AMR for rolling 3-month periods and examined the proportion who were classified as low risk (AMR>.5), high risk (AMR<.5) and no medication claims (no asthma medication claims). Using logistic regression, we tested how the AMR predicted severe exacerbations.

Results: 214,452 eligible children were identified. The mean age is 7.8 yrs. 8-9% had a high risk AMR in any given period. High risk AMR is associated with increased odds of a severe exacerbation in the subsequent 3 months (compared to all other children) (OR 1.7-1.9 depending on time period evaluated).

Conclusions: In this analysis of Medicaid insured children with asthma, we found that the AMR is a reliable predictor of exacerbations. This will inform the development of an AMR-based risk assessment and communication intervention.

Background

Asthma is an ideal disease for population health management (defined as monitoring of health data to deploy interventions with the goal of improving the health of the population) given the evidence-based guidelines, the underutilization of effective therapies, the disease prevalence and associated healthcare costs.(1-3) In order for population health management

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to be effective, we must be able to accurately and efficiently identify high risk patients so that costly interventions can be targeted to those most likely to benefit.(4) The asthma medication ratio (AMR) is a promising risk prediction tool. The AMR (number of controller medication claims/(number of controller medication claims + number of rescue medication claims)) can be calculated using pharmacy claims data. It has previously been shown to be an accurate predictor of emergency department (ED) visits and hospitalizations for asthma in adults and children.(5-9)

In an effort to translate the AMR from a quality care metric to an actionable point of care risk assessment tool, we recently established that a 3-month rolling AMR calculation period can be used to accurately assess risk for ED visit or hospitalization in a cohort of commercially insured children with asthma.(10) This approach allows for near real-time risk assessment using the most recent claims data available without relying on 12 months of data. This could be feasible in large cohorts of patients with pharmacy claims data available at the bedside via Surescripts or similar electronic health record pharmacy data vendor. The AMR, when calculated monthly on a rolling basis, could be used to identify the highest risk children to allow for adherence interventions prior to exacerbations that lead to costly ED visits and hospitalizations. Our previous assessment of the rolling 3-month AMR was limited to commercially-insured children. Prior to implementing an intervention based on AMR risk assessment, it is important to study the rolling calculation method in Medicaid funded children as well. Previous studies have identified disparate asthma medication adherence patterns in the two groups that could impact the AMR's prediction potential. (2, 8, 11) Additionally, lower socioeconomic status has persistently been shown to be associated with higher asthma prevalence.(12) Payment structures for the two categories of children are quite different with Medicaid funded children having no medication co-pays while commercially insured patients often have substantial out of pocket costs for medications. These differences could potentially affect medication adherence patterns. There are no previous studies assessing the rolling AMR in Medicaid insured children.

The objective of this study is to conduct a longitudinal examination of the rolling 3 month asthma medication ratio in Medicaid insured children with asthma. We hypothesize that we will identify a similar association between high risk AMR and severe exacerbation as was found in the commercial insurance analysis. Additionally we hypothesize overall higher rates of high risk AMR periods in this Medicaid insured population compared to our previous analysis of commercially insured children with asthma, based on previous studies highlighting socioeconomic disparities in children with asthma. Overall, these analyses will further advance our understanding of the AMR as a potentially actionable risk assessment tool.

Methods

Study Cohort

To identify all children for whom the AMR would be a potentially valid risk assessment tool in this retrospective analysis, we first identified all asthma medication claims from the Truven Health MarketScan® Medicaid pharmacy claims databases for 2013 and 2014 using National Drug Code (NDC) numbers. The MarketScan® Medicaid Database represents

seven million Medicaid enrollees from multiple states. Patients age 2-17 yrs with any claim for an ICS-containing medication were eligible for inclusion. In this study, having a claim for an ICS-containing medication is a proxy for persistent asthma. Because this approach to identifying the cohort of children eligible for AMR measurement is relatively new, we determined the proportion of our cohort that meets Healthcare Effectiveness Data and Information Set (HEDIS) persistent asthma criteria. HEDIS criteria for persistent asthma have traditionally been used to identify patients in administrative claims data. To qualify as a persistent asthmatic under the HEDIS criteria a patient must meet one of the following measures in a 12 month period: 1) at least 4 asthma medication-dispensing events, 2) at least 2 asthma medication-dispensing events and 4 asthma-related outpatient visits, 3) at least 1 asthma-related hospitalization, or 4) at least 1 asthma-related emergency department visit. (13)

We defined each patient's study index date as the date of his or her first ICS-containing medication claim during the study period. Patients with less than 360 (12×30) days of continuous insurance enrollment after their index date were excluded. Patients with a diagnosis of Cystic Fibrosis (ICD-9 277.XX) at any time during the study period were excluded. We then identified all inpatient and emergency department visit claims with a primary diagnosis of asthma (ICD-9 493.XX) from the medical claims file for each included patient. Patient age in years (at index date and categorized into three categories representing preschool aged children (2-6 yrs), school aged children (7-12 yrs) and adolescents (13-17 yrs)), sex (self-reported on Medicaid application), race/ethnicity (self-reported on Medicaid application as the following four categories: white/black/Hispanic/other), season of index date (Winter = Dec-Feb, Spring= Mar-May, Summer= Jun-Aug, Fall= Sept-Oct) were included as covariates. We determined the proportion of the cohort that had an ICS versus an ICS/LABA as their index controller. To get an idea of the overall healthcare utilization patterns of our cohort we determined the proportion who had any ED visit or hospitalization with a primary diagnosis of asthma within 15 months of the index date.

AMR Classification—The AMR is the primary independent variable. Using the formula: number of controller medication claims/(number of controller medication claims + number of rescue medication claims), an AMR was calculated for each patient, in rolling 3-month time periods (months 1-3, 2-4, 3-5 etc). AMRs can range from 0 (only rescue medication claims) to 1 (only controller medication claims) or be “no medication claims” (no rescue or controller medication claims) for any given time 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 were not included as index controllers. Oral albuterol was not included as a rescue medication.

Based on previous studies, AMRs were classified as high-risk (<0.5), low-risk (0.5) or no medication claims for each calculation time period. (6, 8, 10) We chose a dichotomous risk classification based on previous large studies that have shown that the ideal cut-point is anywhere between 0.4-0.6. This cut point can vary by age and other patient factors. In order to operationalize the AMR in a streamlined manner one cut point for high risk that applies to the whole population is ideal. Because of our definition of index date, the AMR values for

the first time period (those that include month 1) are artificially inflated. This influenced further analytical decisions.

Population-level AMR distribution through 12 study months was plotted using stacked bar charts. In order to determine, at the population level, if early risk classification remains the same through the year, patients in each category (high-risk, low-risk and no medication claims) for the first analyzable rolling 3-month time period (month 2-4) were tracked at the population level over the course of the year. We determined the proportion of patients who remained in the same risk category from one month to the next.

To identify differences in AMR risk classification by patient characteristics likely to influence medication adherence patterns or disease severity, AMR classification changes over time were also assessed by age group, season of index date and category of index controller (ICS versus ICS/LABA).

Outcome Variable

ED visits and hospitalizations with a primary diagnosis of asthma (ICD-9 codes 493.XX) were identified from the MarketScan® Medicaid medical claims file. Having any ED visit or hospitalization for asthma in a given outcome time period was the primary dichotomous outcome variable for this study.

Preliminary Outcome Analysis

To begin to understand how patients with no medication claims AMRs should be classified in future interventional studies, we compared proportions of patients with any ED visit or hospitalization for asthma between those classified as high-risk, low-risk and no medication claims in the first analyzable rolling 3-month time period. Chi-square tests were used to identify any statistically significant differences.

Regression Analysis

To determine the strength of any statistically significant relationship between AMR risk category and the dichotomous outcome of ED visit/hospitalization we ran simple logistic regression models with the dichotomous outcome of ED visit/hospitalization in 3-month outcome windows and the independent variable of AMR risk category (high risk, low risk and no medication claims). Each AMR calculation period and its corresponding outcome period were tested in individual models.

Results

Demographics

214,452 patients aged 2-17 yrs with at least one claim for an ICS or ICS/LABA and at least 360 days of continuous enrollment after their index date were identified in 2013 MarketScan Medicaid data. Of these patients, 59% were male, had a mean age of 7.8 yrs; 44% were aged 2-6 yrs, 40% aged 7-12 yrs and 16% age 13-17 yrs. 50% of assigned index dates were in the winter (Dec-Feb). 85% of children had an ICS as their index controller. 16.6% of patients had at least one ED visit or hospitalization with a primary diagnosis of asthma within 15

months of their study index date. Sixty-seven percent of the patients in our cohort qualified as persistent asthmatics using the HEDIS criteria. (Table 1) The proportion of the cohort meeting HEDIS criteria for persistent asthma by AMR category is shown in Figure 1.

AMR Classification—Using a rolling 3-month AMR calculation period and excluding the month 1 values due to the index date definition including ICS medication claim which results in AMR inflation, an average of 9% of the population were identified as high risk in each calculation period while 51% were no medication claims (no asthma meds filled during the AMR calculation period). (Figure 2)

The majority of children who were classified as no medication claims initially continue to have no medication claims AMRs through month 12. Similarly, the majority who were low risk initially remain low risk through month 12. The biggest departures from original classification occur in the high-risk group, with only 28% remaining high risk through month 12. (Figure 3). AMR classification differences by age group, index controller season and index controller type are shown in Figures 4-6. Of note, a higher proportion of children with ICS/LABA as their index controller had a high risk AMR throughout the year (12% for ICS/LABA patients v 8.5% for ICS patients) and a lower proportion had no medication claims AMRs throughout the year (37% for ICS/LABA patients v 54% for ICS patients).

Preliminary Outcome Analysis

The patients with no medication claims AMRs had the lowest proportion of events (13.9%) which was significantly lower than the proportion with events in both the low risk (18.1%) and high risk (25.0%) AMR categories ($p<.0001$). This finding suggests that those children with no medication claims AMRs were likely to be children with inactive asthma, at low risk for exacerbation. (Table 2)

Regression Analysis

In simple regression analysis children with a high risk AMR were 1.7-1.9 times more likely to have an ED visit or hospitalization in the subsequent 3 month time period compared to children with low risk or no medication claims AMRs. (Table 3)

Discussion

This longitudinal analysis of the AMR in a large cohort of Medicaid funded children with asthma adds further support to the use of the AMR as a risk prediction tool. Overall 9% of the study population had a high risk AMR in any given measurement period. We identified a significant association between the 3-month AMR and subsequent severe exacerbation. These findings are consistent with previous AMR studies which have shown a significant association between the AMR and acute exacerbations when measured in fixed time period (5-9) and our previous analysis of the rolling 3-month AMR in commercially insured children. (10)

While the strength of the relationship between AMR and severe exacerbations (represented by ED visits and hospitalizations) is similar between this cohort and our previously published analysis of commercially insured children, (10) there were some notable

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differences between the two populations. The most striking difference is the higher proportion of patients with severe exacerbations during the study period in the Medicaid cohort (16.6%) compared to the commercially insured cohort (4.5%). This could represent differing health care seeking behavior patterns or that the Medicaid cohort has more severe asthma than the commercially insured cohort. Additionally, we found a higher proportion of the Medicaid population had a high risk AMR in any given time period when compared to the commercially insured cohort (9% versus 5% respectively). This could reflect differences in controller medication adherence between the two populations or differences in prescribing practices. When compared to the commercially insured cohort, this Medicaid insured cohort had a higher average proportion of low risk AMR patients (40% in publically insured versus 36% in commercially insured) and a lower proportion of no medication claims AMR patients (51% in Medicaid insured v. 59% in commercially insured).

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The higher proportion of patients with ED visits or hospitalizations during the study period compared to commercially insured patients is likely multifactorial. Previous studies have demonstrated higher asthma morbidity in patients with lower socioeconomic status.(14) These patients are less likely to have ready access to a medical home and are likely facing challenges related to single-parent households, lack of transportation, and home environmental triggers that are out of their control.(15-18) Hughes et al recently showed that poor housing quality was independently associated with asthma diagnosis and ED visits. (14) All of these factors could contribute to poorer disease control and higher rates of severe exacerbation. Additionally, it is possible that the healthcare-seeking behavior between the two groups is different; the Medicaid cohort may be more likely to seek care in the emergency department due to difficulty accessing primary care during regular business hours. Previous studies have shown that Medicaid insured children have higher rates of ED use than commercially insured children. (19, 20)

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It is also possible that the children in the Medicaid cohort have more severe baseline disease than the children in the commercially insured cohort (outside of factors related to trigger exposure and medication adherence). The study periods in the two populations were the same and patients qualified for cohort entry in the same way. It is interesting to note that approximately the same proportion of children in each cohort had an ICS/LABA as their index controller, which could be used as a proxy for “severe” asthma in this administrative claims data analysis.

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Another possibility is that the poorer medication adherence in the Medicaid cohort (as estimated by the significantly higher rate of high risk AMRs each month) is responsible for the difference in severe exacerbation rates between the two groups. Asthma controller medications are effective at reducing risk for severe exacerbation leading to ED visits and hospitalizations.(21, 22) It is likely a combination of more severe baseline disease, poorer medication adherence and increased exposure to environmental triggers that has led to the fourfold higher rate of ED visits and hospitalizations in the Medicaid cohort compared to the contemporaneous commercially-insured cohort. The goal of this analysis was to further our understanding of the AMR as a risk prediction tool so that it can be used to identify the highest risk kids for targeted case management. These results confirm that the 3-month rolling AMR can be used in commercially and Medicaid insured populations alike.

However, some of these differences in the two populations deserve further investigation, particularly the significantly higher rate of ED visits/hospitalizations and the higher proportion of children with high risk AMRs.

There are several limitations to this study. First, we use administrative claims data for this analysis. Although claims data lack the clinical detail that might be found in other data sources such as electronic health records, they remain the most accurate source for determining medication adherence patterns in large populations of patients. Because we are not able to determine prescription writing from these data, we do not know the role patient-filling behavior has in controller medication non-adherence. Patterns of poor adherence could in fact represent under-prescribing by the providers. Prescriptions that are not paid by the insurance company (i.e. free samples) would not be included in these data. Another limitation is the dataset lacks geographical information, therefore we are unable to determine trends related to geographic differences. Finally, we used a novel method to identify our cohort for inclusion. Rather than relying on the HEDIS criteria for persistent asthma that requires up to 12 months of claims data to apply, we included all patients with any ICS-containing claim. Based on current asthma guidelines, treatment with ICS is reserved for patients who are clinically determined to have persistent asthma.(23, 24) Therefore we believe this approach has face validity. However, it should be noted that only approximately two thirds of our study population met HEDIS criteria for persistent asthma. Those that met our inclusion criteria but did not meet HEDIS criteria are likely those patients who are prescribed an ICS one time perhaps during an acute viral illness but do not have recurrence of wheezing. In our proposed AMR risk classification system, these patients would move to the “no medication claims” category and therefore be considered low risk for acute exacerbation.

In this longitudinal examination of the asthma medication ratio in a large cohort of commercially-insured children with asthma, we have determined that the rolling 3-month AMR approach will identify approximately 9% of children as high risk in any given time period. Children with an AMR <0.5 are more likely to have an ED visit or hospitalization in the subsequent 3 month period. These findings further support the rolling 3-month AMR as an appropriate method for identifying children at high risk for imminent exacerbation regardless of public or private insurance status.

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Abbreviations:

AMR	asthma medication ratio
ICS	inhaled corticosteroid
ED	Emergency Department

LABA	long-acting beta agonist
HEDIS	Healthcare Effectiveness Data and Information Set

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

Figure 2.
AMR Classification through 12 months for a Cohort of Medicaid Insured Children with Asthma (n=214,452)

a. 3-month AMR No medication claims in months 2-4 (n=103,305)

b. 3-month AMR High Risk in months 2-4 (n=17,635)

c. 3-month AMR Low Risk in months 2-4 (n=93,512)

Figure 3.
AMR Classification through 12 Months in a Cohort of Medicaid Insured Children with Asthma

a) Age 2-6 years: Rolling 3-month AMR Calculation Period

b) Age 7-12 years: Rolling 3-month AMR Calculation Period

c) Age 13-17 years: Rolling 3-month AMR Calculation Period

Figure 4.
AMR Classification through 12 Months for a Cohort of 214,452 Medicaid Insured Children with Asthma by Age Group

a) Winter Index Date

b) Spring Index Date

c) Summer Index Date

d) Fall Index Date

Figure 5.

AMR Classification through 12 Months for a Cohort of 214,452 Medicaid Insured Children with Asthma by Season of Index Date

1) Patients with ICS as Index Controller

2) Patients with ICS/LABA as Index Controller

Figure 6.
AMR Classification through 12 Months for a Cohort of 214,452 Medicaid Insured Children with Asthma by Index Controller Category

Table 1.

Demographics of Children in the Truven MarketScan Medicaid Database with at Least One ICS Containing Medication Claim in 2013-2014 (N=214,452)

Characteristic	Value (n)
Age, y, mean/median (range)	7.8/7 (2-17)
Age category	
2-6 y	94,585 (44%)
7-12 y	85,424 (40%)
13-17y	34,443 (16%)
Sex	
Male	126,840 (59%)
Female	87,612 (41%)
Race/Ethnicity	
White	87,034 (41%)
Black	88,635 (41%)
Hispanic	17,858 (8%)
Other	20,925 (10%)
Index Controller Category ^a	
ICS	181,829 (85%)
ICS/LABA	32,623 (15%)
Index Controller Season ^b	
Winter (Jan-Mar)	107,073 (50%)
Spring (Apr-Jun)	42,602 (20%)
Summer (Jul-Sept)	31,725 (15%)
Fall (Oct-Dec)	33,052 (15%)
Meets HEDIS Criteria ^c	
Yes	143,292 (67%)
No	71,160 (33%)
Proportion with Any Event ^d Within	
3 mo of index date	17,952 (8.4%)
6 mo of index date	23,006 (10.7%)
9 mo of index date	28,182 (13.1%)
12 mo of index date	32,475 (15.1%)
15 mo of index date	35,619 (16.6%)

^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 HEDIS criteria for persistent asthma

^d Any ED visit or hospitalization with a primary diagnosis of asthma (ICD-9 493.XX), cumulative

Table 2.

Population Level Frequency of Emergent Events by AMR Category in Months 2-4 (Rolling 3)

Month 2-4 AMR (Rolling 3 Month AMR)	N	Proportion with any event between index date and study month 15	
Missing	103,305	13.9%	<.0001
.5 (Low Risk)	93,512	18.1%	
< .5 (High Risk)	17,635	25.0%	

Table 3.

Odds of an Asthma related ED visit or Hospitalization for a Child with an AMR<0.5 using a 3-month rolling calculation period (n=241,452)

Rolling 3 Month AMRs^b	3 Month Outcome Period^a OR (95% CI)
Mo 2-4	1.9 (1.7-2.0)
Mo 3-5	1.9 (1.8-2.0)
Mo 4-6	1.9 (1.7-2.0)
Mo 5-7	1.8 (1.7-2.0)
Mo 6-8	1.7 (1.6-1.9)
Mo 7-9	1.8 (1.7-2.0)
Mo 8-10	1.8 (1.7-1.9)
Mo 9-11	1.7 (1.6-1.8)
Mo 10-12	1.7 (1.6-1.9)

^aEach outcome period begins the month following the last month of the AMR calculation period

^bModel compares children with a high risk AMR to children with low risk AMR and children with missing AMR in given AMR period