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ASTHMA OUTCOMES



Characteristics and outcomes associated with two asthma quality of care measures

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ABSTRACT

Objective: We investigated asthma quality measures to understand patient characteristics associated with non-attainment of quality care and measure the association with asthma-related emergency department (ED) visits or inpatient hospitalizations (IPs).

Methods: Using administrative data from ALL Kids, Alabama's Children's Health Insurance Program, from 2013 to 2019 we calculated non-attainment of the Medication Management for Asthma (MMA) and Asthma Medication Ratio (AMR) quality measures. Patient characteristics and asthma-related ED visits and IPs associated with non-attainment of the MMA and AMR measures were assessed using logit regression models and Marginal effects at the mean.

Results: Among 2528 children with asthma, 53.2% failed to attain the MMA measure and 8.5% the AMR measure. Prior asthma-related ED visits or IP stays increased likelihood of non-attainment by 14.8 percentage points (95% CI 8.6–20.9) for MMA and 7.3 percentage points (95% CI 2.8–11.8) for AMR. Among 868 children (34.3%) with three years of continuous enrollment, AMR non-attainment was associated with a 6.1 percentage point increase in ED or IP utilization (95% CI 1.3–10.9), however MMA non-attainment was not associated with either outcome. Prior ED visit/IP stay was associated with a 17.2 percentage point (95% CI 8.3–26.1) increase in the likelihood of a subsequent ED visit/IP stay among those with non-attainment MMA and a 15.5 percentage point increase (95% CI 6.9–24.2) for non-attainment AMR.

Conclusions: Patient characteristics associated with non-attainment of asthma quality measures presents actionable evidence to guide improvement efforts as non-attainment AMR increases the risk of subsequent ED visits and IP stays.

Abbreviations: ED: emergency department; IP: inpatient hospitalization; MMA: Medication Management for People with Asthma; AMR: Asthma Medication Ratio; CI: confidence interval; CMS: Centers for Medicare and Medicaid Services; NQF: National Quality Forum; CHIP: Children's Health Insurance Program; PDC: proportion of days covered; FPL: federal poverty level; HEDIS: Healthcare Effectiveness Data and Information Set; NDC: National Drug Codes; ICD: International Classification of Diseases; CPT: Current Procedural Terminology; IPSD: index prescription start date; RUCA: Rural–Urban Community Area

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Introduction

Asthma, the most common chronic respiratory disease among children, is characterized by episodic inflammation and obstruction of the airways, triggering symptoms that include difficulty breathing, coughing, wheezing, and shortness of breath (1). The condition affects 6.1 million American children and is a frequent reason for emergency department (ED) visits and inpatient hospitalizations (IP) (1). Managing asthma

requires a combination of monitoring, education, lifestyle modification, and medications (2). Two classes of medications treat asthma: long-term control medications (i.e. “controller medications”) and quick-relief medications. Controller medications treat the underlying inflammation and include corticosteroids, leukotriene modifiers, immunomodulators, and long-acting beta-agonists (2). Quick-relief medications treat acute symptoms and exacerbations and include anticholinergics, short-acting beta-agonists, and

systemic corticosteroids (2). The heterogeneity and intensity of asthma symptoms make optimal control of the disease challenging (3). Therefore, the treatment and management of asthma is complex and highly individualized. Typically, a combination of controller and quick-relief medications (taken as necessary) is recommended (1). While the exact combination and number of medications may vary, less frequent reliance on quick-relief medications is an indicator of optimally controlled asthma.

Due to both the high prevalence of asthma among children and the high cost of asthma-related health service utilization, efforts to measure and improve the quality-of-care for asthma patients are crucial. The Centers for Medicare and Medicaid Services (CMS) began tracking the Child Core Set of quality measures with the enactment of the Children's Health Insurance Program Reauthorization Act of 2009 (4). Within this measurement system, which was strongly based on measures endorsed by the National Quality Forum (NQF), quality of asthma care was designated a top priority (5). However, measurement of asthma care quality has evolved over time. Initially, the measure considered only ED visits for asthma (NQF #1381). From 2013 until 2017, the quality measure called Medication Management for Asthma (MMA; NQF #1799) was used, which assessed how many days a child meeting the definition of persistent asthma had long-term controller medications based on a calculation of the proportion of days covered (PDC). In late 2017, the NQF removed the endorsement of the MMA measure and it was consequently retired from the Child Core Set (6,7). The revised Child Core Set now includes a new NQF-endorsed measure known as the asthma medication ratio (AMR; NQF #1800) that captures the ratio of controller medications to all asthma medications (i.e. both controller and quick-relief medications) for children with persistent asthma. With nearly all state Medicaid and CHIP programs reporting, it is important to monitor any implications to quality resulting from these measurement changes. Furthermore, understanding characteristics associated with non-attainment of quality is important to ensure all populations are receiving high-quality care. Finally, continuous evaluation of quality measures is necessary to ensure that there is a measurable benefit to achieving quality of care targets.

In light of the changes to the CMS Child Core Set measures in 2018, we investigated two asthma quality measures: the MMA and AMR measures. First, we described characteristics of children associated with non-attainment of quality targets. Second, we identified characteristics associated with

discordant measures of the quality of asthma care—that is, those children who attained one measure target but did not attain the other—to identify potential gaps in the new measure. Finally, we evaluated whether subsequent ED visits or IPs were associated with non-attainment of quality care.

Methods

Data and study population

We used administrative data from ALL Kids, Alabama's separate CHIP, from 2013 through 2019. Throughout this time period, ALL Kids coverage was available in 12-month enrollment periods to Alabama children 18 years and younger with family incomes above Medicaid limits up to 317% of the federal poverty level (FPL). Annual premiums and copayments for services were determined by family income as a percentage of FPL. Analyses for this study was conducted with approval by the Institutional Review Board at the University of Alabama at Birmingham.

Measures construction

We used the definitions of the MMA and AMR quality measures provided to state CHIP and Medicaid programs in the CMS technical specifications manual (8). In the case of the retired MMA measure, we used a historical version of the technical manual. Both measures use administrative data to retrospectively identify a cohort of children with persistent asthma. Specifically, children must be continuously enrolled for at least two years and meet at least one of four criteria from the Healthcare Effectiveness Data and Information Set (HEDIS) definition of asthma during *each* year of enrollment: (1) a hospitalization with primary diagnosis of asthma, (2) an ED visit with primary diagnosis of asthma, (3) four outpatient visits with any diagnosis of asthma, or (4) four prescriptions (including refills) for HEDIS-specified asthma controller medications. Criteria need not be consistent across years. Exclusions are made for coverage gaps over 45 days, those with no asthma medications during the measurement year, and for certain chronic respiratory conditions including emphysema, chronic obstructive pulmonary disease, or cystic fibrosis.

All codes to identify asthma in each measurement year were derived from the HEDIS value sets, with medications identified using National Drug Codes (NDCs), asthma diagnoses and exclusion diagnoses using International Classification of Diseases (ICD)

versions 9 and 10, and procedures identified using Current Procedural Terminology (CPT) codes. Additionally, as part of our longitudinal analysis, revenue center codes 450–459 and CPT codes 99281–99288 were used to define ED visits not resulting in admission and hospital facility claims were used to identify IP stays.

The MMA measure is based on the PDC of controller medications and calculated based on the number of days from a defined index prescription start date (IPSD), the earliest date any asthma controller medication was dispensed, to the end of the measurement year. For example, an IPSD on January 1, 2017, would have a measurement period of 365 days for the 2017 measurement year. Next, the number of days in which an asthma controller medication was available was calculated based on the number of dispensing events and days' supply for each event. For example, a child receiving 10 medications with 30 days' supply each would have 300 days covered, and the PDC would be calculated as 300 days covered divided by 365 days during the measurement period, equal to 0.82 or 82%. The PDC accounts for overlapping prescriptions such that two medications dispensed on the same day, each with 30 days, will contribute 30 total days to the PDC numerator. Likewise, if during a 60-day period a child filled two 30-day supplies of different controller medications 5 days apart (e.g. when a physician switches a medication), the total days covered for this period would be the number of non-overlapping days, or 35 days. Historically, states were required to report the percentage of children who attained each of two MMA thresholds ($\geq 50\%$ and $\geq 75\%$). We created a binary indicator of non-attainment denoting MMA below the threshold of 50%, corresponding to the lowest rate publicly reported in the Child Core Set.

The AMR measure is calculated as the ratio of long-term control asthma medications to the overall number of asthma medications received during the measurement year. For example, a child with 6 controller medication fills and 4 quick-relief medications fills would have an AMR calculated as 6 divided by (6 + 4), and equal to 0.6 or 60%. For consistency with the evidence-based publicly reported rates, we created a binary indicator for non-attainment based on whether children were below an AMR threshold of 50% (9,10). Binary definitions of children's asthma-related care that was below either the MMA or AMR measure targets will be referenced throughout this manuscript as "non-attainment."

Variables

Enrollee characteristics were derived from ALL Kids administrative systems. Eligibility categories based on FPL and race/ethnicity were identified from self-reported information provided by enrollee families on the enrollment application. Categories corresponding to cost-sharing group included "low fee," with family incomes up to 156% FPL, "fee" between 157% and 208% FPL, and "expansion" between 209% and 317% FPL. A fourth group of children, the "no fee" group were exempted from cost-sharing by federal criteria, such as Native American heritage. We grouped enrollees into three mutually exclusive race/ethnic categories: non-Hispanic white, African American, and other (including Hispanic ethnicity). Rural-urban residence was based on ZIP code of enrollment address categorized into Rural-Urban Commuting Area (RUCA) codes corresponding to urban, large rural, small rural, isolated, or unknown. The HEDIS asthma criteria which designated entry into the measure cohort was transformed into mutually exclusive categories based on hierarchy of (1) asthma-related ED or hospitalization, (2) outpatient visit with at least 2 medications, (3) ≥ 4 asthma medications.

We identified a subset of children with an additional year of continuous enrollment (i.e. at least three years total). We then identified asthma-related ED visits/IP during that year using diagnosis codes from the HEDIS value sets.

Statistical analysis

Frequencies and bivariate statistical tests were conducted using χ^2 tests of enrollee characteristics on the binary outcome of measure non-attainment. To test agreement across measure definitions, McNemar's χ^2 test was used. Logit models estimated the association of enrollee characteristics and non-attainment for each measure, as well as characteristics associated with measure non-attainment discordance, controlling for all other characteristics. Likewise, logit models were estimated to measure the association of measure non-attainment and subsequent asthma-related ED visits or IP stays. We reported marginal effects at the mean, which is equivalent to the absolute risk difference (e.g. likelihood) and use 95% confidence intervals to assess statistical significance.

Results

From 2013 through 2019, we observed 2528 ALL Kids enrollees who met the HEDIS definition of persistent

asthma and were eligible for measure calculation. This included having at least two years of continuous enrollment and meeting at least one of the defined asthma criteria. Of these children, non-attainment of quality asthma care was observed by 53.2% for the MMA measure and 8.5% for the AMR measure (Table 1). Statistically significant bivariate associations were observed for MMA non-attainment and age, race, and the asthma persistence criteria. For non-attainment of the AMR measure, statistically significant bivariate associations were observed with age, cost-sharing group, and asthma persistence criteria.

Results from logit regression models display the adjusted likelihood of enrollees with non-attainment for each of the measures, MMA and AMR (Table 2). An asthma-related ED visit or IP stay in the previous year was consistently associated with non-attainment, as these children were 14.8 percentage points more likely to have MMA non-attainment (95% CI 8.6,

20.9) and 7.3 percentage points (95% CI 2.8, 11.8) more likely to have AMR non-attainment asthma care. We observed a consistent effect of age on the quality of asthma care as children aged 12–18 had a greater likelihood of MMA non-attainment of 7.1 percentage points (95% CI 3.1, 11.1) and AMR non-attainment of 6.6 percentage points (95% CI 3.6, 8.6). African American children had an estimated 13.9 percentage point greater likelihood of non-attainment for the MMA measure (95% CI 9.5, 18.2) compared to white children. However, a similar association was not observed for the AMR measure.

Results from logit regression models estimating characteristics of discordant measure attainment are shown in Table 3. Being African American was associated with a 14.0 percentage points greater likelihood to have attained the AMR target but not MMA within the same measurement year than whites (95% CI 9.6, 18.4). Additionally, children with a prior asthma-related

Table 1. Characteristics of children with persistent asthma and bivariate associations with two quality measures: medication management of asthma (MMA) and asthma medication ratio (AMR).

	MMA N = 2528		p	AMR N = 2520		p
	Non-attainment	Attainment		Non-Attainment	Attainment	
Total, n (%)	1346 (53.2)	1182 (46.8)		214 (8.5)	2306 (91.5)	
Age in years, n (%)			.007			<.001
5–11	816 (60.6)	778 (65.8)		98 (45.8)	1493 (64.7)	
12–18	530 (39.4)	404 (34.2)		116 (54.2)	813 (35.3)	
Sex, n (%)			.140			.600
Male	857 (63.7)	719 (60.8)		137 (64.0)	1434 (62.2)	
Female	489 (36.6)	463 (39.2)		77 (36.0)	872 (37.8)	
Race, n (%)			<.001			.750
Non-Hispanic White	603 (44.8)	661 (55.9)		103 (48.1)	1158 (50.3)	
Non-Hispanic African American	534 (39.7)	323 (27.3)		73 (34.1)	780 (33.8)	
Other (incl. Hispanic)	209 (15.5)	198 (16.8)		38 (17.8)	368 (16.0)	
Cost-sharing Group			.420			.003
Low fee	352 (26.2)	289 (24.5)		72 (33.6)	565 (24.5)	
Fee	543 (40.3)	460 (38.9)		83 (38.8)	918 (39.8)	
No fee	11 (0.8)	11 (0.9)		4 (1.9)	18 (0.8)	
Expansion	440 (32.7)	422 (35.7)		55 (25.7)	805 (34.9)	
Rural–Urban commuting area, n (%)			.810			.190
Urban	961 (71.4)	848 (71.7)		168 (78.5)	1638 (71.0)	
Large rural	161 (12.0)	133 (11.3)		19 (8.9)	272 (11.8)	
Small rural	126 (9.4)	115 (9.7)		15 (7.0)	226 (9.8)	
Isolated	93 (6.9)	78 (6.6)		12 (5.6)	157 (6.8)	
Unknown	5 (0.4)	8 (0.7)		–	13 (0.6)	
Other chronic comorbidities, n (%)	201 (15.0)	198 (16.8)	.210	41 (19.2)	358 (15.5)	.160
Asthma persistence criteria, n (%)			<.001			<.001
ED/IP visit	187 (13.9)	91 (7.7)		42 (19.6)	234 (10.1)	
≥2 outpatient visits with medications	313 (23.2)	285 (24.1)		36 (16.8)	559 (24.2)	
≥4 asthma medications	846 (62.9)	806 (68.2)		136 (63.6)	1513 (65.6)	
Measurement year, n (%)			.740			.190
2013	472 (35.1)	426 (36.0)		90 (42.1)	805 (34.9)	
2014	163 (12.1)	127 (10.7)		25 (11.7)	264 (11.4)	
2015	107 (7.9)	95 (8.0)		9 (4.2)	193 (8.4)	
2016	138 (10.3)	141 (11.9)		26 (12.1)	253 (11.0)	
2017	232 (17.2)	188 (15.9)		29 (13.6)	391 (17.0)	
2018	216 (16.0)	188 (15.9)		32 (15.0)	368 (16.0)	
2019	18 (1.3)	17 (1.4)		3 (1.4)	32 (1.4)	

Notes. Sample sizes for the measures are not equal due to exclusions in the MMA measure—children are not eligible for this measure if they had no long-term controller medication fills. The AMR measure excludes only children with no medications (long-term controller or fast-acting inhaler). AMR, asthma medication ratio; ED, emergency department; IP, inpatient; MMA, medication management of asthma.

Table 2. Estimated marginal effects and 95% confidence intervals at the mean (i.e. likelihood) of characteristics associated with non-attainment of two quality measures: medication management of asthma (MMA) and asthma medication ratio (AMR).

	MMA N=2528		AMR N=2520	
	Likelihood of non-attainment	95% CI	Likelihood of non-attainment	95% CI
Age in years				
5–11	REF		REF	
12–18	7.1	3.1, 11.1	6.6	3.6, 8.6
Sex, n (%)				
Male	REF		REF	
Female	−3.0	−7.1, 1.0	−0.9	−3.2, 1.4
Race				
Non-Hispanic White	REF		REF	
Non-Hispanic African American	13.9	9.5, 18.2	−0.5	−2.9, 1.9
Other (incl. Hispanic)	3.7	−2.1, 9.5	0.5	−2.8, 3.9
Cost-sharing Group				
Low fee	REF			
Fee	−0.6	−5.8, 4.6	−2.5	−5.6, 0.6
No fee	−4.1	−25.8, 17.7	6.0	−9.0, 21.0
Expansion	−2.5	−8.1, 3.0	−3.9	−7.3, −0.6
Rural–urban commuting area				
Urban	REF		REF	
Large rural	3.6	−2.4, 9.6	−3.1	−6.2, −0.1
Small rural	1.9	−4.8, 8.6	−2.9	−6.3, 0.6
Isolated	2.8	−5.0, 10.6	−2.8	−6.7, 1.1
Unknown	−10.9	−38.2, 16.4	–	–
Other chronic comorbidities	−3.9	−9.4, 1.6	0.8	−2.2, 3.7
Asthma persistence criteria				
ED/IP visit	14.8	8.6, 20.9	7.3	2.8, 11.8
≥2 outpatient visits with medications	2.1	−2.6, 6.9	−1.6	−4.1, 0.9
≥4 asthma medications	REF		REF	

Notes. Marginal effects estimated by logit regression with robust clustering on standard errors to account for children with repeated episodes. Sample sizes for the measures are not equal due to exclusions in the MMA measure—children are not eligible for this measure if they had no long-term controller medication fills. The AMR measure excludes only children with no medications (long-term controller or fast-acting inhaler). Model also controls for measurement year.

AMR, asthma medication ratio; 95% CI, 95% confidence interval; ED, emergency department; IP, inpatient; MMA, medication management of asthma.

ED visit/IP stay were 7.2 percentage points more likely to have AMR attainment but MMA non-attainment in the same measurement year than children who had four or more asthma medication fills (95% CI 0.7, 13.6).

A subset of 868 children (34.3% of the total cohort) with persistent asthma had an additional year of continuous enrollment to measure the association between non-attainment of each measure and subsequent asthma-related ED visits/IP stays (Table 4). There was no statistically significant association with asthma-related ED visits/IP stays and MMA non-attainment. However, AMR non-attainment was associated with a 6.1 percentage point increase in the likelihood of an asthma-related ED visit/IP stay (95% CI 1.3, 10.9). For each measure, an asthma-related ED visit/IP stay during the measurement year was associated with a subsequent asthma-related ED visit/IP stay. In the model with MMA non-attainment as the main explanatory variable, a measurement year ED visit/IP stay was associated with a 17.2 percentage points increase in risk compared to children with medications alone (95% CI 8.3, 26.1). In the model with AMR non-attainment, a similar association of 15.5 percentage points

greater risk of an ED visit/IP stay was observed (95% CI 6.9, 24.2). In models with the estimated effect of non-attainment at each level of asthma persistence criteria (interaction effects), a statistically significant association was observed among children with prior ED visits/IP stays, regardless of measure attainment (Table 5). However, the likelihood of an ED visit/IP stay was greatest for non-attainment of MMA (25.4 percentage points vs 20.3 percentage points) and AMR (38.7 percentage points vs 19.5 percentage points).

Discussion

Our study resulted in several important findings. First, we observed the MMA measure was challenging to attain—over half the children studied had MMA non-attainment. Conversely, fewer than 10% had AMR non-attainment. Second, we observed older children and those with recent asthma-related ED visits or IP stays were more likely to have non-attainment. Third, children with AMR non-attainment were more likely to have subsequent asthma-related ED/IP visits compared with children with measure attainment. Lastly, we observed prior asthma-related ED/IP visits were

Table 3. Frequency, estimated marginal effects, and 95% confidence intervals at the mean (i.e. likelihood) of characteristics associated with a discordance on two asthma quality measures: non-attainment on the medication management of asthma (MMA) and attainment for the asthma medication ratio (AMR).

	AMR attainment and MMA non-attainment		
	Frequency	Likelihood	95% CI
Age in years, <i>n</i> (%)			
5–11	718 (63.4)	REF	
12–18	415 (36.6)	1.2	–2.9, 5.2
Sex, <i>n</i> (%)			
Male	719 (63.5)	REF	
Female	414 (36.5)	–1.9	–5.9, 2.1
Race, <i>n</i> (%)			
Non-Hispanic White	503 (44.4)	REF	
Non-Hispanic African American	458 (40.4)	14.0	9.6, 18.4
Other (incl. Hispanic)	172 (15.2)	3.4	–2.4, 9.1
Cost-sharing group			
Low fee	281 (24.8)	REF	
Fee	462 (40.8)	2.0	–3.3, 7.2
No fee	7 (0.6)	–11.1	–31.5, 9.2
Expansion	383 (33.8)	0.8	–4.8, 6.4
Rural–urban commuting area, <i>n</i> (%)			
Urban	797 (70.3)	REF	
Large rural	141 (12.4)	6.7	0.6, 12.7
Small rural	111 (9.8)	4.5	–2.2, 11.2
Isolated	79 (7.0)	4.6	–3.4, 12.6
Unknown	5 (0.4)	–2.4	–30.9, 26.2
Other chronic comorbidities, <i>n</i> (%)	163 (14.4)	–4.4	–9.9, 1.2
Asthma persistence criteria, <i>n</i> (%)			
ED/IP visit	144 (12.7)	7.2	0.7, 13.6
≥2 outpatient visits with medications	274 (24.2)	3.0	–1.6, 7.7
≥4 asthma medications	715 (63.1)	REF	

Note. Marginal effects estimated by logit regression with robust clustering on standard errors to account for children with repeated episodes. Model also controls for measurement year.

AMR, asthma medication ratio; 95% CI, 95% confidence interval; ED, emergency department; IP, inpatient; MMA, medication management of asthma.

associated with an increased likelihood of ED/IP visits in addition to the role of measure non-attainment.

Quality measure reporting by states is critically important to characterize the structures, processes, or outcomes relevant to quality goals, and is useful for monitoring performance, describing trends, driving internal quality activities, or holding entities accountable (11). However, rarely do the measures contain sufficient detail to adequately guide quality improvement efforts. Using the same administrative data for calculating the publicly reported measures, we provide additional enrollee characteristics associated with sub-optimal performance. Our findings that older children and those having a prior ED/IP visit have a higher likelihood of non-attainment of asthma quality care is consistent with prior research (12–14). However, it is not clear from administrative data whether this is the result of poor care delivered by providers or patient behavior and thus we are unable to identify more specific barriers to attaining quality goals. However, evidence on enrollee characteristics associated with measure non-attainment can be used as actionable evidence for providers, case-managers, and health plan administrators.

A substantial body of literature supports measuring asthma management with administrative data using the AMR (9,10,15–19). Compared with several

candidate measures, patients with a medication ratio ≥ 0.5 (i.e. higher proportion of controller medications to overall) have lower risk of emergency department care, favorable quality-of-life scores, better control, and lower symptom severity (9,10). Thus, AMR of ≥ 0.5 has become the standard indicator of asthma quality of care from administrative data (10). In fact, the lack of evidence along with concerns over measure construction led the NQF to remove endorsement of the PDC measure (NQF #1799), making AMR the default measure of asthma quality reporting by Medicaid and CHIPs (6). Our observations are consistent with this prior research and demonstrate the advantage of AMR over MMA with regards to distinguishing non-attainment and associated adverse outcomes (15,16).

Notably, we observed low asthma medication adherence overall, consistent with other populations previously studied (20–21). This primarily affects quality measurement defined by MMA. It is possible that the heterogeneity of the underlying reasons why enrollees may have low medication adherence could explain our observation that MMA non-attainment was not associated with an increased likelihood of subsequent asthma-related ED/IP visits, whereas AMR non-attainment was. Furthermore, we observed particularly high non-attainment of MMA among African

Table 4. Among enrollees with three years of continuous enrollment, the frequency, estimated marginal effects, and 95% confidence intervals at the mean (i.e. likelihood) of non-attainment of quality measure targets associated with an asthma-related emergency department (ED) or inpatient (IP) visit.

	Had an ED/IP Visit	MMA Non-attainment		AMR Non-attainment	
		Estimated Likelihood of ED/IP	95% CI	Estimated Likelihood of ED/IP	95% CI
Total, <i>n</i> (%)	59 (6.8)				
MMA non-attainment	33 (55.9)	2.6	−0.5, 5.8	–	–
AMR non-attainment	11 (18.6)	–	–	6.1	1.3, 10.9
Age in years, <i>n</i> (%)					
5–11	40 (67.8)	REF		REF	
12–18	19 (32.2)	−2.7	−6.0, 0.6	−2.8	−6.0, 0.4
Sex, <i>n</i> (%)					
Male	36 (61.0)	REF		REF	
Female	23 (39.0)	0.8	−2.5, 4.1	0.6	−2.7, 3.9
Race, <i>n</i> (%)					
Non-Hispanic White	24 (42.4)	REF		REF	
Non-Hispanic African American	26 (44.1)	1.9	−1.6, 5.3	2.5	−1.1, 6.1
Other (incl. Hispanic)	8 (13.6)	1.4	−3.8, 6.5	1.7	−3.5, 6.9
Cost-sharing group					
Low fee	6 (10.2)	REF		REF	
Fee	28 (47.5)	0.9	−4.0, 5.9	0.4	−5.0, 5.7
No fee	1 (1.7)	5.1	−10.7, 20.8	1.3	−10.9, 13.6
Expansion	24 (40.7)	0.9	−4.3, 6.1	0.3	−5.3, 6.0
Rural–urban commuting area, <i>n</i> (%)					
Urban	45 (76.3)	REF		REF	
Large rural	7 (11.9)	1.1	−4.1, 5.9	1.7	−4.2, 7.6
Small rural	2 (3.4)	−3.2	−8.2, 1.8	−3.2	−8.2, 1.9
Isolated	5 (8.5)	2.0	−5.4, 9.5	2.1	−5.7, 9.8
Unknown	–	–			
Other chronic comorbidities, <i>n</i> (%)	12 (20.3)	2.4	−1.6, 6.5	2.1	−1.9, 6.1
Asthma persistence criteria, <i>n</i> (%)					
ED/IP visit	20 (33.9)	17.2	8.3, 26.1	15.5	6.9, 24.2
≥2 outpatient visits with medications	11 (18.6)	−0.4	−3.7, 5.8	−0.2	−3.6, 3.2
≥4 asthma medications	28 (47.5)	REF		REF	

Notes. Marginal effects estimated by logit regression with robust clustering on standard errors to account for children with repeated episodes. Model also controls for measurement year.

AMR, asthma medication ratio; 95% CI, 95% confidence interval; ED, emergency department; IP, inpatient; MMA, medication management of asthma.

Table 5. Among enrollees with three years of continuous enrollment, the predicted margins (i.e. likelihood) of an asthma-related emergency department (ED) or inpatient (IP) visit at the mean of all other covariates.

	Estimated likelihood of ED/IP	95% CI	Estimated likelihood of ED/IP	95% CI
MMA non-attainment	2.6	−0.6, 5.9	–	–
AMR non-attainment	–	–	10.2	0.4, 20.0
Asthma persistence criteria for those with non-attainment				
ED/IP visit	25.4	13.3, 37.6	38.7	15.3, 62.1
≥2 outpatient visits with medications	4.0	0.1, 7.8	25.3	0.8, 49.8
≥4 asthma medications	7.4	4.0, 10.7	9.1	−1.3, 19.5
Asthma persistence criteria for those with attainment				
ED/IP visit	20.3	8.0, 32.5	19.5	10.5, 28.4
≥2 outpatient visits with medications	5.2	1.4, 9.0	4.0	1.4, 6.6
≥4 asthma medications	3.5	1.5, 5.5	4.9	3.0, 6.7

Notes. The main effect of quality non-attainment on (MMA) and asthma medication ratio (AMR) is adjusted for individual characteristics and interacted with asthma persistence criteria. Marginal effects estimated by logit regression with robust clustering on standard errors to account for children with repeated episodes. Model also controls for measurement year.

AMR, asthma medication ratio; 95% CI, 95% confidence interval; ED, emergency department; IP, inpatient; MMA, medication management of asthma.

American enrollees. However, we did not observe African Americans to be disproportionately more likely to have asthma-related ED/IP visits as a result. This contrasts with prior research that has identified low-income minority children to have a greater frequency of asthma-related visits (22–23). Although there was a difference observed in meeting quality

thresholds between African American and white children for the MMA measure, a similar disparity does not appear for the new AMR measure. Given the MMA measure is no longer publicly reported via the Child Core Set, it is likely quality measurement in this manner will become rare. However, although non-attainment of MMA does not appear to increase

adverse events such as ED/IP visits, additional research may be needed to better understand factors associated with non-attainment among African Americans. In particular, because this is driven by low asthma medication adherence, consideration of any potential implications this might have in terms of asthma management is important.

We observed prior ED/IP visits were more predictive of subsequent ED/IP visits than non-attainment of either quality measure. However, attainment of the quality measure targets attenuates the magnitude of this effect. Prior research has shown that management of asthma improves over time with stable coverage for many children (24). Our finding raises questions as to whether AMR or MMA can adequately measure quality of care among children with prior asthma ED visits or IP Stays. Perhaps these children have greater or lesser disease severity, irregular exposure to environmental triggers, or face significant barriers to optimal quality care. Further investigation of heterogeneity between this population as it pertains to managing asthma is warranted.

Our findings must be interpreted considering their limitations. Although binary thresholds facilitate the identification of non-attainment, they may lack precision versus measuring quality on a continuous scale. However, binary non-attainment is consistent with Medicaid/CHIP public quality reporting. Administrative claims data are limited in the ability to capture socio-demographic factors, including parent/caregiver decisions and/or other barriers to care such as social health needs. Although these are important, they are not readily available to Medicaid and CHIPs to guide quality improvement. Disease severity is limited in quality measures and is not well characterized using claims data. Our focus was limited to one potential outcome of care quality, ED visits/IP stays, although other benefits or adverse outcomes may be important. Finally, the generalizability beyond Alabama's CHIP may be limited, however, at least 13 other states have similar separate CHIP programs.

Conclusions

Persistent asthma as indicated by an asthma-related ED visit/IP stay increases the likelihood of non-attainment of quality and the risk of subsequent ED visits/IP stays, regardless of whether quality was attained. Special consideration may be needed to better understand this population and develop more optimal recommendations for clinical asthma management. Although the NQF's decision to endorse the AMR measure is supported by the evidence that lacking AMR attainment is associated with increased risk of ED visits/IP stays, the MMA

measure could still be useful in conjunction with AMR. Children with discordant measure attainment, that is those who attained AMR but not MMA, may represent children with low medication adherence. Given the racial disparity we observed, this population may warrant monitoring and additional research to better understand the extent to which asthma is being managed from a clinical perspective.

Declaration of interest

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