

# Predictors of Hospital Reuse Among Publicly Insured Children Hospitalized for Status Asthmaticus

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**BACKGROUND:** Asthma is a common cause of pediatric hospitalization. Nonadherence to asthma medications is associated with worse outcomes; however, there is a paucity of data regarding posthospitalization prescription filling and hospital reuse. Our objective was to identify patients at risk for hospital reuse after being hospitalized for asthma.

**METHODS:** This is a retrospective study of patients with asthma who were discharged from a children's hospital in which we use Medicaid claims data to evaluate prescription fills within 30 days and 12 months. Chart reviews were used for demographics, chronic asthma severity, admission severity, and hospital reuse. *t* and  $\chi^2$  tests were performed for continuous and categorical variables. A generalized linear mixed model was fitted to predict the odds of hospital reuse, which was defined as requiring an emergency department visit or rehospitalization. Survival analysis using log-rank testing was used for modeling the time to hospital reuse.

**RESULTS:** Fifty-four percent of patients discharged with asthma had hospital reuse within 1 year of discharge. There was no association between hospital reuse and prescription filling for systemic steroids (odds ratio [OR] 1.30; confidence interval [CI]: 0.85–2.00; *P* = .21) or controller medications (OR 1.5; CI: 0.92–2.52; *P* = .10). There was a higher number of controller and systemic steroid prescription fills over 12 months for patients with hospital reuse. The factors associated with greater odds of hospital reuse were severity of chronic asthma diagnosis (*P* = .03) as well as African American race (OR 1.92; CI: 1.17–3.13; *P* = .01).

**CONCLUSIONS:** For Medicaid-insured patients discharged with asthma, worse chronic asthma severity and African American race were associated with greater odds of hospital reuse. Decreased prescription filling was not associated with greater odds of hospital reuse.

## ABSTRACT

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Asthma is 1 of the most common chronic childhood illnesses, affecting  $\leq 7$  million children in the United States.<sup>1</sup> It is also 1 of the most frequent causes of pediatric visits to the emergency department (ED) and hospitalization, accounting for  $> 150\,000$  hospitalizations annually.<sup>2,3</sup> The annual national cost of pediatric asthma hospitalization alone is  $> \$500$  million.<sup>4</sup> The incidence of rehospitalization within 365 days of an index hospitalization for asthma-related illness ranges from 16% to 29%.<sup>5-7</sup> Asthma-related ED visits after an index hospitalization have an even higher reported incidence of  $\leq 41\%$ .<sup>8</sup> There is a paucity of data regarding posthospitalization asthma controller adherence as it relates to the incidence of rehospitalization and return ED visits.

The use of asthma controller medications, namely inhaled corticosteroids (ICSs), decreases the risk of ED visits and hospitalization by 30% to 50% in patients with asthma.<sup>9-12</sup> The use of ICSs has also been shown to be inversely related to rehospitalization.<sup>13-15</sup> Kenyon et al<sup>14</sup> specifically showed a reduction in rehospitalization for 13% of children who filled ICS prescriptions over a 90-day postdischarge interval.

Nonadherence to asthma controller medications is a common cause of persistent, uncontrolled symptoms and increased costs in care.<sup>16-19</sup> Prescription filling is a commonly used measure for assessing controller medication adherence. However, it is known that prescription filling of asthma controller medications is poor, with  $\leq 33\%$  of patients not filling their prescriptions even when prescribed by a specialist.<sup>11,12,20-22</sup> However, the relationship between poor prescription filling and hospital reuse is unclear. Studies are limited in identifying the acute severity of the hospitalization and chronic asthma severity as they relate to hospital reuse.<sup>6,14,15</sup> Although important, these metrics of acute and chronic asthma can be challenging to obtain because they often require manual abstraction.

Our goal in this study was to identify patients at greater odds of hospital reuse on the basis of a cohort of patients with

index hospitalizations for status asthmaticus. We hypothesized that decreased prescription filling of ICSs within 30 and 365 days after discharge would be associated with increased odds of hospital reuse (ie, requiring an ED visit or rehospitalization) within 365 days. We also hypothesized that hospital reuse would be associated with a higher severity of illness during the index hospitalization and the patient's chronic asthma severity.

## METHODS

### Study Design and Setting

This was a retrospective chart review with a secondary analysis of Medicaid claims data of patients who were hospitalized from June 2014 through December 2015 with a primary diagnosis of asthma and admitted to a children's hospital on an asthma clinical pathway (hereafter referred to as pathway). This facility is a 332-bed, urban, free-standing, tertiary-care children's hospital that serves as a large regional referral center and is associated with an academic medical center. Status asthmaticus is the second most common cause of pediatric hospital medicine admissions, averaging  $> 500$  inpatient admissions annually. Patients were eligible for the pathway if they had a primary admission diagnosis of asthma and met the following inclusion criteria: age  $\geq 2$  years and absence of a comorbid respiratory disease, including pneumonia that required parenteral antibiotic therapy, cystic fibrosis, bronchopulmonary dysplasia, chronic aspiration, or another chronic lung disease. All patients admitted to the pathway received asthma education regarding chronic management and the use of prescribed medications in a standardized format provided by a trained nurse case manager or respiratory therapist. Additional methodologic details of the institution's pathway are available.<sup>23</sup>

Institutional review board approval was granted for this study.

### Data Sources

We performed a health record abstraction of demographic variables. Manual chart abstraction was performed to obtain physician orders, physician documentation,

and discharge medication reconciliation. Prescriptions at discharge were manually obtained with chart review by reviewer A.L.M. Prescriptions at the study institution are electronically written and printed, physically signed, and given to the patient. Electronic prescribing was not used at the time of this study, and medications were not required to be in hand at the time of discharge. Hospital reuse with an ED visit or rehospitalization for an asthma-related illness was recorded. All patients in this cohort were admitted to the pathway and manually tracked. There was missing patient identification data for 2 patients who were excluded.

### Medicaid Database

We accessed our state Medicaid database for prescription charges through collaboration with our local care coordination organization. The Medicaid database was queried by a single reviewer (L.W.), who matched the prescription provided at discharge with prescription fill charges within a 30-day period from discharge. Additionally, the cumulative number of controller medication and systemic steroid prescription fills within 365 days after discharge from the hospital was recorded. For the cumulative controller prescription fills, a controller medication was defined as any medication with an ICS component excluding leukotriene receptor antagonist (LTRA) monotherapy. No patients in this study were given a dose of or prescription for dexamethasone before discharge as their systemic corticosteroid.

### Measures

Demographic variables were categorized according to standard practices (age as a discrete integer in number of years and biological sex as male or female) and a preliminary review of frequency distributions (race and ethnicity as non-Hispanic and African American, non-Hispanic and white, Hispanic, and other or declined). Demographic variables, including age, sex, and race and ethnicity, were obtained at the time of patient registration.

Chronic asthma severity was operationalized into 5 categories. Four categories aligned with the following National Heart, Lung, and Blood Institute

(NHLBI) guidelines: severe, moderate, or mild persistent and intermittent.<sup>24</sup> Chronic asthma diagnosis severity was manually abstracted in a chart review of the most senior provider's documentation that was available at the time closest to discharge. If patients were diagnosed with persistent asthma without a specific designation, they were labeled as "other severity and/or persistent."

Hospitalization denotes the index hospitalization of a patient with the primary diagnosis of asthma and includes the severity of admission, admission service, length of stay (LOS), and prescription of systemic steroids and controller medication at discharge. Severity of admission was operationalized dichotomously (yes or no) in terms of whether ICU care or continuous albuterol were required on hospitalization. Admission service was operationalized dichotomously in terms of whether care from a pediatric hospital or pulmonary medicine service was received. LOS was defined as the number of days within the hospital during the index hospitalization as a discrete integer that was calculated by using a subtraction of calendar dates from admission to discharge. Prescription of controllers and systemic steroids at discharge was operationalized dichotomously (yes or no).

Prescription fill variables were operationalized dichotomously (yes or no) in terms of whether patients obtained prescribed controller medications and systemic steroids within 30 days of discharge from their index hospitalizations. A discrete integer measure of controller medications was also collected (number of prescription fills within 12 months).

Hospital reuse was operationalized dichotomously (yes or no) and continuously (within 365 calendar days from the index hospitalization). We defined a hospital reuse as an ED visit or hospitalization with the administration of systemic steroids and confirmatory physician documentation as markers of asthma exacerbation.<sup>25</sup>

### Analysis Plan

To identify characteristics associated with hospital reuse, *t* and  $\chi^2$  tests were used for

continuous and categorical variables, respectively. For this analysis we only used the characteristics of the first hospitalization (Table 1). In Table 1 we display the results of comparing patients with and without hospital reuse. Repeat hospitalizations were considered another observation of hospital reuse. However, in our analyses, we adjusted for the fact that multiple hospitalizations from the same patient were more associated than hospitalizations between patients. This was done by fitting a mixed model with a random intercept.

A generalized linear mixed model with a random intercept for binary outcomes was also fitted to investigate if any of the demographic and clinical variables are

predictors of the occurrence of hospital reuse. To examine the predictors of time to first hospital reuse (in days), Kaplan-Meier estimates were obtained, and log-rank tests were conducted.

In each outcome, models were first fitted separately for each predictor variable (ie, the models were unadjusted). Predictors that were found to be significant in the unadjusted models were included in an adjusted multiple regression model.  $P < .05$  was deemed significant. Analyses were done with SAS version 9.4 (SAS Institute, Inc, Cary, NC).

### RESULTS

A total of 480 patients were included in these analyses, with 551 hospitalizations for

**TABLE 1** Study Cohort Demographics by Hospital Reuse

	Total	With Reuse	No Reuse	<i>P</i>
Based on total patients, <i>n</i> (%)	480	237 (49.4)	243 (50.6)	—
Average age, <i>y</i> , (SD)	6.9 (3.6)	7.0 (3.7)	7.0 (3.5)	.97
Sex, <i>n</i> (%)				.70
Male	306 (63)	149 (63)	157 (65)	
Female	174 (36)	88 (37)	86 (35)	
Race, <i>n</i> (%)				.009
African American	377 (79)	199 (84)	178 (74)	
White	100 (21)	38 (16)	62 (26)	
Other or missing	3 (0.6)	0 (0)	3 (1)	
Based on all hospitalizations	551	295	256	—
Chronic disease severity, <i>n</i> (%)				.01 <sup>a</sup>
Intermittent	82 (15)	29 (10)	53 (21)	
Mild persistent	101 (18)	48 (16)	53 (21)	
Moderate persistent	200 (36)	116 (39)	84 (33)	
Other severity or persistent	50 (9)	28 (9)	22 (9)	
Severe persistent	78 (14)	49 (17)	29 (11)	
Severity not recorded	40 (7)	25 (8)	15 (6)	
Severe index hospitalization, <i>n</i> (%)				.34
No	415 (75)	227 (77)	188 (73)	
Yes	136 (25)	68 (23)	68 (27)	
Average LOS, <i>d</i> , (SD)	1.6 (1.2)	1.6 (1.0)	1.7 (1.4)	.07
Average <i>d</i> to fill controller prescription (SD) <sup>b</sup>	1.6 (4.2)	1.7 (4.1)	1.4 (4.2)	.42
Average <i>d</i> to fill systemic steroid prescription (SD) <sup>c</sup>	1.2 (3.5)	1.6 (4.2)	0.8 (2.5)	.01
Average controller prescription fills over 12 mo (SD)	3.5 (3.1)	3.8 (3.2)	3.3 (2.9)	.04
Average systemic steroid prescription fills over 12 mo (SD)	2.3 (2.5)	3.0 (3.0)	1.6 (1.5)	<.0001

—, not applicable.

<sup>a</sup> *P* excludes severity and unrecorded data.

<sup>b</sup> A total of 299 patients (163 with reuse and 136 without reuse) are missing this information.

<sup>c</sup> A total of 152 patients (83 with reuse and 69 without reuse) are missing this information.

status asthmaticus. The mean age of all patients on index hospitalization was 6.9 years; 63% of the patients were boys, and 79% were African American (both Hispanic and non-Hispanic; Table 1). With regard to chronic asthma severity based on all hospitalizations, 14% of patients were classified as having severe persistent asthma, 36% were classified as having moderate persistent asthma, 18% were classified as having mild persistent asthma, 15% were classified as having intermittent asthma, and 9% were classified as having other severity and/or persistent asthma. Twenty-five percent of patients were classified as a severe admission, and 94% were admitted to the pediatric hospital medicine service. The mean LOS for all hospitalizations was 1.6 days (SD 1.2 days).

In this cohort of patients who were hospitalized with the principal diagnosis of status asthmaticus, 67% of patients received a prescription for controller medications, and 98% received a prescription for systemic steroids (Table 2). Prescription filling data revealed that 70% of patients filled their asthma controller prescriptions within 30 days and that the average number of days to fill was 1.6 (SD 4.2 days). In terms of systemic steroid prescription filling, 74% of patients filled their systemic steroid prescriptions, and the average number of days to fill was 1.2 (SD 3.5 days; Table 1).

Hospitalizations (including index hospitalizations) were as follows: 49

patients (10.2%) had 2 hospitalizations, 8 patients (1.6%) had 3 hospitalizations, and 4 patients (0.8%) had 4 hospitalizations. The overall percentage of patients with hospital reuse (including ED visits and/or rehospitalization within 365 days after hospitalization) was 54%. The average number of days to hospital reuse was 201 (SD 164 days).

When comparing demographics of patients with and without hospital reuse, there was a significant difference found for the following variables: race and ethnicity, chronic disease severity, days to fill a systemic steroid, and average controller and systemic steroid prescription fills over 1 year. Particularly for chronic asthma severity, intermittent asthma represented only 10% of cases in patients with hospital reuse compared with 21% of cases in those without hospital reuse. In addition, for those with hospital reuse, the average days to fill systemic steroid prescriptions and the average controller and systemic steroid prescription fills over 1 year were significantly higher.

Bivariate analysis revealed that chronic asthma severity and race and ethnicity were found to be significant predictors of experiencing hospital reuse. Patients with a diagnosis of intermittent asthma had lower odds of hospital reuse compared with those with moderate persistent asthma (odds ratio [OR] 0.41; 95% confidence interval [CI]: 0.23–0.73;  $P = .003$ ), severe persistent asthma (OR 0.34; 95% CI: 0.17–0.69;

$P = .004$ ), and other severity and/or persistent asthma (OR 0.44; 95% CI: 0.20–0.97;  $P = .04$ ; Table 3). With respect to race and ethnicity, non-Hispanic African American patients had approximately double the odds of hospital reuse relative to non-Hispanic white patients (OR 2.1; 95% CI: 1.31–3.35;  $P = .002$ ). Thirty-day posthospitalization prescription filling rates for controller medications ( $P = .10$ ) and systemic steroids ( $P = .21$ ) were not found to be significant predictors of hospital reuse (Table 3). Patients with a severe index hospitalization did not have greater odds of hospital reuse ( $P = .37$ ). Fitting an adjusted model with chronic asthma severity and race still resulted in these 2 predictors being significant. The general conclusions compared with those from the unadjusted analysis model were the same, with the exception being the pairwise comparison between the categories of other severity or persistent asthma and intermittent chronic asthma severity, which did not reach significance.

Despite the significant differences noted in the overall risk of hospital reuse, no demographic or clinical factors were found to be significantly associated with the time from index hospitalization to hospital reuse by using log-rank tests (results not presented).

## DISCUSSION

In our single-center study of Medicaid-insured patients who were discharged with status asthmaticus from a tertiary-care children's hospital, the factors that increased the odds of hospital reuse were asthma severities of moderate and severe persistent and race and ethnicity. There was no significant association between prescription filling of systemic steroids or asthma controller medications 30 days after an index hospitalization for status asthmaticus and future rehospitalization or ED visits. Interestingly, in our study, a higher number of asthma controller medication fills within a 12-month period was associated with increased hospital reuse (Table 1). This likely reflects an underlying severity of chronic disease because hospital reuse was associated with more annual controller fills and chronic asthma severity.

**TABLE 2** Prescriptions Provided at Discharge and Filling Rates

	Prescriptions Provided at Discharge, <i>n</i> (%) <sup>a</sup>	Prescriptions Filled Within 30 Days of Discharge, <i>n</i> (%) <sup>b,c</sup>
Controller prescribed, all categories	370 (67)	252 (68)
ICS	249 (45)	175 (70)
ICS or long-acting $\beta$ -agonist	43 (8)	26 (60)
ICS and LTRA	40 (7)	28 (70)
ICS or long-acting $\beta$ -agonist and LTRA	30 (5)	23 (77)
No controller prescribed	181 (32)	NA
Systemic corticosteroids prescribed	540 (98)	399 (74)

NA, not applicable.

<sup>a</sup> Percentage based on all hospitalizations ( $N = 551$ ).

<sup>b</sup> Percentage of prescriptions filled based on *n* from previous column.

<sup>c</sup> Data obtained by local care coordination organization from the state Medicaid database.

**TABLE 3** Factors Predicting Hospital Reuse

	Unadjusted Model		Adjusted Model <sup>a</sup>	
	OR (CI)	P	OR (CI)	P
30 d systemic steroid fill, filled versus unfilled	1.30 (0.85–2.00)	.21	NA	NA
30 d controller medication fill, filled versus unfilled	1.5 (0.92–2.52)	.10	NA	NA
Admission service, pulmonary versus hospital medicine	0.48 (0.21–1.09)	.07	NA	NA
Severity of admission, severe versus nonsevere	1.2 (0.79–1.84)	.37	NA	NA
Chronic asthma severity <sup>b</sup>		.02		.03
Severe persistent versus intermittent	0.34 (0.17–0.69)	.004	0.37 (0.18–0.75)	.007
Moderate persistent versus intermittent	0.41 (0.23–0.73)	.003	0.43 (0.24–0.78)	.006
Other severity or persistent versus intermittent	0.44 (0.20–0.97)	.04	0.46 (0.21–1.00)	.0504
Race, white versus African American	2.09 (1.31–3.34)	.002	1.92 (1.17–3.13)	.01
Sex, male versus female	1.05 (0.72–1.55)	.78	NA	NA

NA, not applicable.

<sup>a</sup> The adjusted model includes only race and chronic asthma severity because these were the significant variables in the unadjusted model.

<sup>b</sup> Only significant ( $P < .05$ ) pairwise comparisons were presented in the unadjusted model. For comparison purposes, we looked at the same pairwise comparisons in the adjusted model.

prescribers in other studies.<sup>27,28</sup> It is unclear whether this reflects true nonadherence or discontinuation of therapy by outpatient providers due to improved asthma control. However, the NHLBI guidelines recommend outpatient follow-up in 3-month intervals in anticipation of stepping down therapy.<sup>24</sup> This makes it unlikely that outpatient physicians are discontinuing therapy in the 12 months after a hospitalization for status asthmaticus. It seems more likely that patients have poor posthospitalization transitions to primary care, as has been noted in previous studies after ED visits.<sup>29</sup>

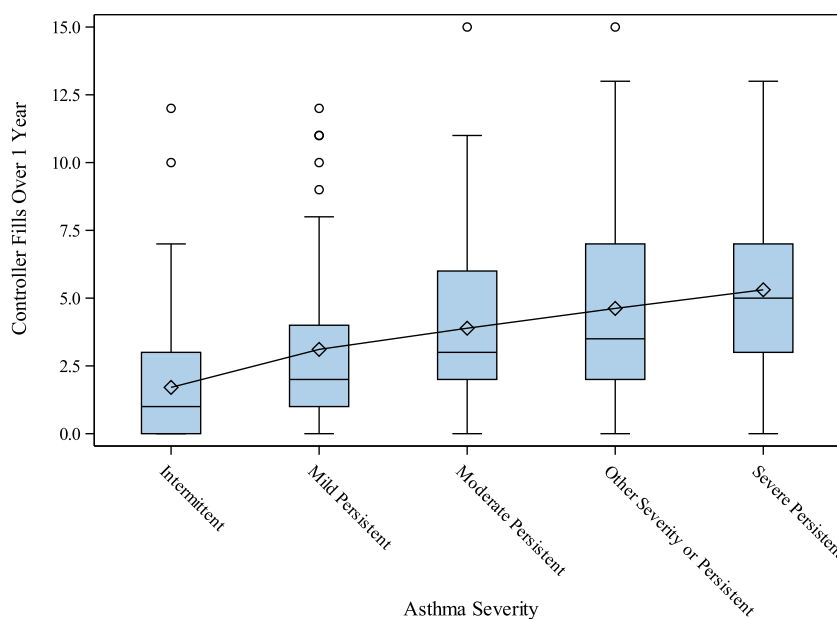
Fifty-four percent of patients in our study had either a rehospitalization or ED visit, which is comparable to findings from other studies.<sup>5,6,8</sup> Our study involved a Medicaid-insured cohort and included ED visits in the definition of a hospital reuse. This could have contributed to the high rates of hospital reuse given the increased ED use among Medicaid-insured patients.<sup>30</sup> There is large variation in the rate of hospitalizations for asthma exacerbations across children's hospitals in general, which highlights the opportunities to focus on hospital use in the asthma population.<sup>5</sup>

In our study, we also highlighted the known disparity in care associated with African American race and hospital reuse.<sup>8,31–34</sup> In particular, we noted that there was twice the likelihood of hospital reuse among African American patients without any effect of race on prescription filling or time to hospital reuse. Identifying a high-risk patient population as a focus for transitional care interventions may be of benefit in decreasing hospital reuse in asthma.<sup>35,36</sup> Specifically, addressing social determinants of health may help to provide improved transitional care and reduce hospital reuse.<sup>37</sup> All the patients in our study were on Medicaid insurance, and thus the differences in hospital reuse would suggest there are social determinants of health that are not captured in hospital-level data. Researchers in other studies have highlighted the effect of race on asthma care and revealed a difference in management as a factor contributing to worse outcomes.<sup>38–40</sup> This is an important area of continued research to further

In Fig 1, we demonstrate the increasing number of asthma controller medication fills of patients with increasing levels of chronic asthma severity.

In our study, we highlight poor prescription filling patterns in our population, as is demonstrated in the low number of controller medications filled over the

12-month period after a hospitalization for status asthmaticus. This has also been seen in previous studies in which ICS prescription filling among pediatric patients with commercial insurance is assessed.<sup>26</sup> Asthma controller medication fill rates were similar to those seen by outpatient prescribers and outpatient specialty



**FIGURE 1** Box and whisker plot of cumulative controller prescription fills 1 year after discharge by chronic asthma severity. The diamond symbols designate means. Means are connected to show trends. The circle symbols designate outliers, which are  $>1.5$  times the interquartile range. The edges of the boxes designate controller prescription fill scores of 25% and 75%. The middle line is the median value.



elucidate the etiologies of health disparities and strategies to counteract them.

We had several limitations related to the retrospective nature of the study and the difficulty in measuring medication adherence. This is a single-center study with patients on Medicaid insurance and thus may not be generalizable. Nonetheless, our study reveals similar rates of prescription filling in our cohort to those noted in other studies of asthma prescription filling.<sup>41</sup> Secondly, in this study, we were not able to obtain data on ED visits or hospitalizations at other facilities and thus run the risk of underestimating hospital reuse. Because this facility is the only tertiary children's care center in the state and the majority of patients were from the surrounding metropolitan area, we feel that we captured most hospital reuse.<sup>5-8</sup>

Prescription filling is an imprecise measurement of adherence because it cannot be used to distinguish between the use of medication versus "stockpiling" medication.<sup>42,43</sup> Despite the risk of overestimating adherence, prescription filling data are a useful, noninvasive method of evaluating nonadherence and have been routinely used in the literature as a proxy for medication adherence.<sup>44</sup> Another limitation of our study was the inability to determine if a prescription was provided by the inpatient physician because an identical prescription from a primary care provider or subspecialist may have been included. However, this would still likely reflect an effect of hospitalization on prescription filling behaviors and would be important to recognize with respect to hospital reuse.

In this study, we assessed prescriptions for ICS provided at discharge, which occurred for 67% of hospitalizations. The number of ICS prescriptions provided was lower than the percentage of patients discharged with a diagnosis of chronic persistent asthma (78%). We believe a factor in this difference was that patients may have already had a controller medication at home and were not provided a new prescription. Similarly, prescription filling of controller medications may be underestimated for patients who were provided a prescription and then did not fill it because they had a controller medication at home that they used for

30 days after discharge. We believe the effect of this to be negligible because the systemic steroid used for the index acute exacerbation had similar filling rates. In addition, appropriate dosing of the ICS based on age, severity, and control based on NHLBI guidelines was not obtained.

## CONCLUSIONS

Our single-center study revealed that 54% of patients discharged with an index hospitalization for status asthmaticus had at least 1 ED visit or rehospitalization at 1 year posthospitalization. Patients with moderate or severe persistent chronic asthma severity relative to intermittent asthma and African American race had greater odds of hospital reuse. In this Medicaid-insured population with status asthmaticus, only 68% and 74% of patients discharged from the hospital filled their prescriptions for asthma controller medications and systemic steroids, respectively, but there was not a significant association between hospital reuse and 30-day asthma medication prescription filling. We found that hospital reuse was associated with more controller prescription fills over 12 months. Our study reveals health care disparities with respect to African American race and pediatric asthma that require further study. Patients with more severe, chronic levels of asthma are an opportunity for future quality-improvement efforts.

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