



Pediatric asthma hospitalizations among urban minority children and the continuity of primary care

Levon H. Utidjian MD, MBI, Alexander G. Fiks MD, MSCE, A. Russell Localio PhD, Lihai Song MS, Mark J. Ramos, Ron Keren MD, MPH, Louis M. Bell MD & Robert W. Grundmeier MD

To cite this article: Levon H. Utidjian MD, MBI, Alexander G. Fiks MD, MSCE, A. Russell Localio PhD, Lihai Song MS, Mark J. Ramos, Ron Keren MD, MPH, Louis M. Bell MD & Robert W. Grundmeier MD (2017): Pediatric asthma hospitalizations among urban minority children and the continuity of primary care, Journal of Asthma, DOI: [10.1080/02770903.2017.1294695](https://doi.org/10.1080/02770903.2017.1294695)

To link to this article: <http://dx.doi.org/10.1080/02770903.2017.1294695>



Accepted author version posted online: 25 Feb 2017.
Published online: 25 Feb 2017.



Submit your article to this journal [↗](#)



Article views: 43



View related articles [↗](#)



View Crossmark data [↗](#)

Pediatric asthma hospitalizations among urban minority children and the continuity of primary care

Levon H. Utidjian, MD, MBI ^{a,b}, Alexander G. Fiks, MD, MSCE^{a,b,c,d}, A. Russell Localio, PhD^e, Lihai Song, MS^f, Mark J. Ramos^a, Ron Keren, MD, MPH^{b,c}, Louis M. Bell, MD^{b,c,d}, and Robert W. Grundmeier, MD^{a,b,c,d}

^aDepartment of Biomedical and Health Informatics, Children's Hospital of Philadelphia, Philadelphia, PA, USA; ^bDepartment of Pediatrics, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA, USA; ^cCenter for Pediatric Clinical Effectiveness, Children's Hospital of Philadelphia, Philadelphia, PA, USA; ^dPediatric Research Consortium, Children's Hospital of Philadelphia, Philadelphia, PA, USA; ^eDepartment of Biostatistics and Epidemiology, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA, USA; ^fHealthcare Analytics Unit, Children's Hospital of Philadelphia, Philadelphia, PA, USA

ABSTRACT

Objective: To examine the effect of ambulatory health care processes on asthma hospitalizations. **Methods:** A retrospective cohort study using electronic health records was completed. Patients aged 2–18 years receiving health care from 1 of 5 urban practices between Jan 1, 2004 and Dec 31, 2008 with asthma documented on their problem list were included. Independent variables were modifiable health care processes in the primary care setting: (1) use of asthma controller medications; (2) regular assessment of asthma symptoms; (3) use of spirometry; (4) provision of individualized asthma care plans; (5) timely influenza vaccination; (6) access to primary healthcare; and (7) use of pay for performance physician incentives. Occurrence of one or more asthma hospitalizations was the primary outcome of interest. We used a log linear model (Poisson regression) to model the association between the factors of interest and number of asthma hospitalizations. **Results:** 5,712 children with asthma were available for analysis. 96% of the children were African American. The overall hospitalization rate was 64 per 1,000 children per year. None of the commonly used asthma-specific indicators of high quality care were associated with fewer asthma hospitalizations. Children with documented asthma who experienced a lack of primary health care (no more than one outpatient visit at their primary care location in the 2 years preceding hospitalization) were at higher risk of hospitalization compared to those children with a greater number of visits (incidence rate ratio 1.39; 95% CI 1.09–1.78). **Conclusions:** In children with asthma, more frequent primary care visits are associated with reduced asthma hospitalizations.

ARTICLE HISTORY

Received 16 September 2016
Revised 12 January 2017
Accepted 8 February 2017

KEYWORDS

Management/control;
pediatrics; prevention

Introduction

Morbidity due to childhood asthma has risen substantially in recent decades with increases in asthma-related mortality, hospitalizations, disability, and cost [1–5]. Despite recent improvements in the arsenal of therapeutics to prevent and treat asthma exacerbations, asthma remains a leading cause of pediatric acute care, accounting for over 157,000 hospitalizations and over 640,000 emergency department (ED) visits annually. An estimated 10.5 million school days are lost annually due to asthma exacerbations, highlighting the broad impact of asthma on 7.1 million affected children [1].

For conditions like asthma, hospitalization has been used as a measure of the quality of outpatient care, with higher rates of asthma-related hospitalization indicating that better outpatient care is necessary [6]. Interventions to improve outpatient asthma care, and thus reduce

hospitalizations, have focused on the individual patient, practice, or system-level. Patient-level interventions include the use of inhaled corticosteroids, which have been shown to improve symptoms and reduce hospitalizations in long-term clinical trials [7]. Population-based studies of patients using these medications, however, have shown no reduction in hospitalizations or reductions greatly limited by real-world adherence issues [8–10]. Few practice-level interventions have been evaluated, though “pay for performance” quality improvement initiatives have been shown to improve some asthma process measures [11,12].

We sought to determine whether specific modifiable outpatient asthma care processes at the practice level are associated with reductions in asthma hospitalization among children in the primary care setting. We also explored the impact of structural factors at the

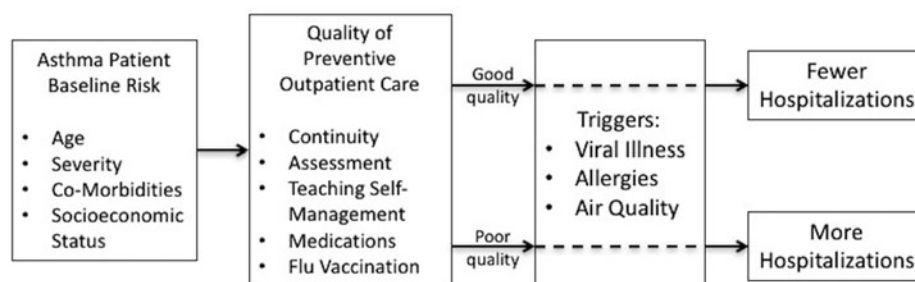


Figure 1. Conceptual model of the relationship between a patient's baseline risk, modifiable care processes and asthma hospitalization.

practice level. Independent of our study, pay for performance incentives related to asthma management were introduced in our health-care system, which provided a natural opportunity to evaluate the impact of these incentives on asthma hospitalizations. Finally, we examined patient-level socio-demographic factors and clinical risk factors that may be associated with asthma hospitalization. Our conceptual model for the relationship between baseline risk, modifiable care processes, and asthma hospitalization is shown in Figure 1.

Methods

Study design

We used a retrospective cohort design to identify modifiable factors that might reduce hospitalization rates for patients with asthma. Access to extensive data at the patient level, as well as some structural factors at the practice level, allowed us to control for potential confounders in the relationships of most interest.

Electronic health records (EHRs; EpicCare[®], Epic Systems Inc., Verona WI) were extracted for children aged 2–18 years who received asthma-related health care from one of the five urban outpatient practices within the Pediatric Research Consortium (PeRC), a two-state practice-based research network with >200,000 children, between Jan 1, 2004 and Dec 31, 2008. During this period the EHR was used to document all aspects of primary care, including diagnoses, medication orders, immunizations, laboratory tests, problem lists, spirometry, and asthma-specific assessment tools. To ensure complete data on hospitalization, analyses were restricted to subjects who resided in zip codes where a previous study had demonstrated that children were known to receive over 90% of their emergency and hospital care from Children's Hospital of Philadelphia (CHOP) [13].

Clinicians identified asthma as a diagnosis at the visit by means of a primary discharge billing code. Each eligible subject was followed from the time of their initial asthma office visit at a primary care location with an asthma diagnosis (International Classification of Diseases [ICD]-9 codes 493.00–493.92) through their

last contact of any type with the primary care practice. A child could have more than one hospitalization during the period of observation.

Study variables

Model building proceeded with the analysis of several categories of independent variables. These variables included patient characteristics known to be associated with asthma outcomes (asthma severity, co-morbidities, body mass index, race, age, gender, and insurance status) and potentially modifiable care processes of interest [regular access to primary care, influenza vaccination, prescriptions for asthma controller medications, clinician assessment of symptoms with a structured asthma control tool (ACT), use of spirometry, personalized asthma care plans (ACP), referral to the Community Asthma Prevention Program (CAPP), and physician pay for performance incentives]. Influenza activity and practice site were also included as covariates in the model. All characteristics were allowed to be time varying with the exception of gender, race and ethnicity. Age was categorized according to published pubertal norms for males and females of each race and was combined with race and gender to form a single interaction variable [14,15].

We decided a priori to exclude ED visits for asthma and prescriptions for bronchodilators from the model. Although these variables are highly associated with both asthma hospitalization and asthma severity, we excluded them because they are also markers for poor asthma control and therefore are on the causal pathway leading to asthma hospitalizations [16]. Adjustment of such factors would induce bias in our estimates of the association of risk factors and outcomes.

At the study sites, clinicians assigned asthma severity based on the National Heart, Lung, and Blood Institute (NHLBI) guidelines as part of routine clinical care [7]. Asthma severity was missing in approximately 16% of the subjects. We imputed 10 sets of values for missing severity using patient characteristics and outcomes as well as clinic location using the method of chained equations [17]. We reviewed a sample of 10 charts where severity was imputed as moderate or severe in 6 or more of the

sets and confirmed that these patients had explicit mention of moderate-persistent or severe-persistent asthma in free text or significant numbers of albuterol prescriptions consistent with high asthma severity. Similarly, we confirmed the accuracy of imputation for 10 children where severity was imputed as intermittent.

Lack of primary health care

Children are expected to receive preventive health-care visits annually throughout childhood. Prior research has examined primary care utilization patterns and found that poor continuity of care over a 24-month time period (failure to consistently see the same primary care provider) was associated with higher utilization of ED and inpatient care [18]. Many children in our cohort received health care less than twice during any given 24-month interval, and so we felt that these children with limited use of primary health care were likely at higher risk of hospitalization. We ultimately chose to include consistent access to primary health care, defined as at least 2 visits in a 24-month period, as a modifiable process of care. All office visits to the primary care location—whether preventive, asthma-related or not—were included in the determination of this binary variable.

Effect modification by severity

We suspected that the association of several key factors (controller medications, ACP, ACT, and spirometry) might modify the association between asthma severity and asthma hospitalization. Therefore, we developed interaction terms to detect effect modification. Influenza vaccination has an additional complication: it is possible that the protective effect of influenza vaccine may differ by asthma severity, but only during the influenza season. In other words, among children with severe persistent asthma, those who are unvaccinated may be much more likely to require hospitalization during the influenza season. In contrast, the hospitalization rate of children with intermittent asthma may be low regardless of influenza vaccine receipt or season. Thus, we also created a composite variable for the association of receipt of influenza vaccine, presence of influenza activity in the community that month, and the severity of the child's asthma. The small number of observations at several levels of these covariates limited our ability to examine all potentially important two-way interactions. Therefore, we attempted to reduce the number of interaction terms, where possible, by grouping levels of factors.

Analytic model

We used a log linear model (Poisson regression) to model the association between the factors of interest and the

number of hospitalizations for asthma during the study period. To evaluate the effect of time-varying exposures, we divided the duration of follow-up into monthly intervals and thus implemented a person-period analysis with the unit of analysis as the patient-month. To account for different time-related trajectories of the risk of hospitalization (for example, increasing or decreasing hospitalization), we divided the entire time period of observation into four categories, corresponding to the periods of implementation of a pay for performance initiative ongoing during the study. Using a piecewise regression model, we then allowed that trajectory to change at each of these periods. We implemented the regression using generalized estimating equations with a working independence correlation structure and robust variance estimates. These analyses were performed in Statistical Analysis System (SAS) proc genmod (SAS Institute, Cary NC, 2008). This method accounted for repeated observations within child, and for possible over dispersion of the data, with relatively few assumptions about the correlation structure over time. All analyses were performed using 10 sets of imputations for asthma severity, and estimates were then combined using Rubin's method to account for both within- and among-imputation components of variance in all reported confidence intervals [19]. We report incidence rate ratios (IRRs) for these analyses.

In addition to the use of interaction terms as described previously, we performed three analyses to further clarify the complex relationship among outcome, risk factors of interest, and asthma severity. First, we fit a model with children of all asthma severity levels. Second, we fit a model limited to children with the highest level of severity. Third, we fit a model limited to children with the three lowest severity levels. In this last model we maintained asthma severity as a covariate, and where indicated, as an interaction term with other factors. This approach allowed us to determine the association between risk factors and asthma hospitalization for children with different levels of asthma severity as well as to assess whether results were consistent across these models. All analyses were performed using SAS v 9.2 (SAS Institute, Cary NC, 2008) and Stata v 11.1 (Stata Corp; College Station TX, 2008). The CHOP Institutional Review Board approved the study and waived the requirement for consent from individual children/families.

Results

Cohort characteristics

Electronic health records from Jan 1, 2004 to Dec 31, 2008 were extracted for all subjects meeting the inclusion criteria. One of the six original study locations was at the edge

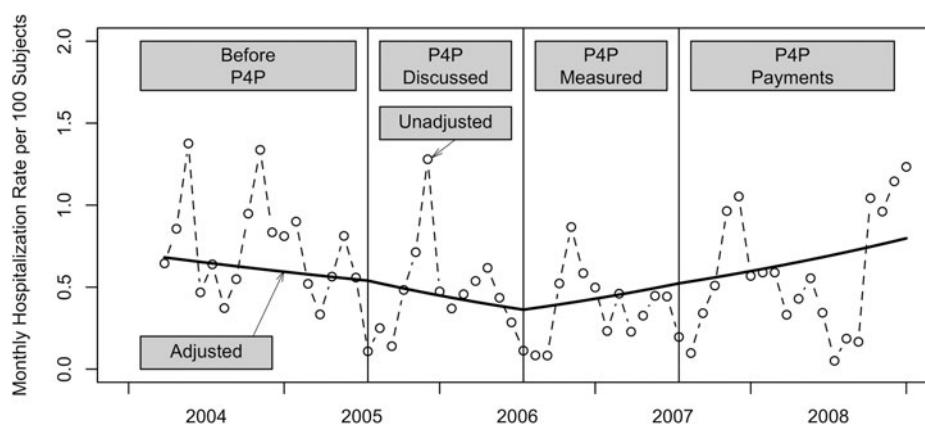


Figure 2. Hospitalization rates for asthma during the study period. Unadjusted (dashed line) and adjusted (solid line) rates are shown per 100 subjects per observation month. P4P = Pay for Performance initiative.

of the hospital's catchment area and was excluded due to the small number of children with asthma residing in a zip code in our study area ($N = 56$). Among the 6,056 children at the remaining five study sites, we excluded 344 children who contributed only 1 month of observation time (i.e. had only a single primary care encounter in the study period), leaving 5,712 subjects for analysis. The average observation period available for each subject was 2.7 years (range 2–65 periods, each period being 4 weeks). This cohort of subjects experienced 989 asthma hospitalizations during the study period. Overall there were 15,401 subject-years of observation and an overall hospitalization rate of 64 per 1,000 children per year. Raw unadjusted and smoothed adjusted hospitalization rates are shown in Figure 2.

Table 1 summarizes demographic characteristics of subjects by care location. As is typical of the population serviced by this inner-city hospital and its city-based primary care sites, most subjects (96%) were African American. This imbalance limited the power to detect racial disparities or differences in hospitalization rate due to race. Male subjects outnumbered female subjects with a ratio of 1.3:1, a ratio similar to other samples of children with asthma in the United States [1,20]. Relationships between asthma hospitalizations, race, gender, and age were examined, which revealed a higher rate of hospitalization among young children (data not shown).

Care processes

Multivariable analysis demonstrated that subjects with no more than one outpatient visit at their primary care location in the 2 years preceding hospitalization ("lack of care") were at a significantly higher risk of hospitalization compared to subjects with two or more primary care visits (IRR 1.39; 95% CI 1.09–1.78). Asthma hospitalization risk was not significantly associated with care location or public vs. private insurance status. Insured subjects

had lower hospitalization risks (public insurance vs. uninsured IRR 0.54, 95% CI 0.25–1.19; private insurance vs. uninsured IRR 0.52, 95% CI 0.23–1.18); however, this association did not reach conventional levels of statistical significance. Finally, the smoothed and adjusted hospitalization rate revealed decreasing hospitalization rates only during the earliest portions of the study prior to the introduction of pay for performance.

Asthma-specific care processes

The presence of certain asthma-specific interventions, including personalized ACPs and referral to CAPP, were associated with a significantly higher risk of hospitalization in this cohort (Table 2). There were no statistically significant associations between asthma hospitalizations and other interventions (influenza vaccination, spirometry measurement, inhaled steroids, and use of a structured ACT). Stratified analysis where subjects with non-severe and severe asthma were examined separately did not significantly alter these relationships.

Asthma severity and co-morbidities

In multivariable analysis an interaction term was included between asthma severity and presence of other major co-morbidities that may affect hospitalization risk (e.g. sickle cell disease, diabetes, trisomy 21, and metabolic disorders). Asthma severity demonstrated the expected strong association with hospitalization rate, and this association was not significantly modified by these co-morbidities. There were also no significant associations between the presence of neurologic or cardiac co-morbidities and asthma hospitalization (data not shown).

There was an association between subjects with body mass index (BMI) below the 5th percentile and hospitalization (IRR 1.70, 95% CI 1.05–2.74). A chart review of all subjects with low BMI indicated that low BMI

Table 1. Distribution of demographic and clinical characteristics of the study cohort by care location.

	Site 1		Site 2		Site 3		Site 4		Site 5		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Total	294		1,699		1,416		624		1,679		5,712	
<i>Race</i>												
Black or African American	251	(85)	1,681	(99)	1,378	(97)	575	(92)	1,610	(96)	5,495	(96)
White	30	(10)	4	(<1)	10	(<1)	26	(4)	17	(1)	87	(2)
Asian or Pacific Islander	6	(2)	3	(<1)	8	(<1)	6	(1)	15	(<1)	38	(<1)
Other or unknown	7	(2)	11	(<1)	20	(1)	17	(3)	37	(2)	92	(2)
<i>Ethnicity</i>												
Hispanic	4	(1)	8	(<1)	10	(<1)	6	(1)	11	(<1)	39	(<1)
<i>Gender</i>												
Female	121	(41)	769	(45)	643	(45)	300	(48)	674	(40)	2,507	(44)
<i>Age*</i>												
2–3 years old	62	(21)	451	(27)	406	(29)	196	(31)	504	(30)	1,619	(28)
4–5 years old	51	(17)	264	(16)	220	(16)	101	(16)	281	(17)	917	(16)
6–12 years old	129	(44)	655	(39)	532	(38)	218	(35)	607	(36)	2,254	(37)
13–18 years old	52	(18)	329	(19)	258	(18)	109	(18)	287	(17)	1,035	(18)
<i>Insurance status*</i>												
Medicaid	88	(30)	1,203	(71)	1,142	(81)	516	(83)	1,306	(78)	4,255	(75)
Private insurance	193	(66)	466	(27)	248	(18)	100	(16)	349	(21)	1,356	(24)
Self pay or unknown	13	(4)	30	(2)	26	(2)	8	(1)	24	(2)	101	(2)
<i>Asthma severity*</i>												
Intermittent	120	(39)	680	(39)	623	(43)	338	(53)	818	(48)	2,579	(45)
Mild-persistent	72	(24)	447	(26)	461	(32)	131	(21)	459	(27)	1,570	(28)
Moderate-persistent	27	(9)	225	(13)	138	(10)	72	(11)	189	(11)	651	(11)
Severe-persistent	2	(<1)	11	(<1)	13	(<1)	19	(3)	13	(<1)	58	(1)
Unknown	72	(24)	331	(19)	183	(13)	68	(11)	200	(12)	854	(15)
<i>Body mass index*</i>												
<5th percentile	2	(<1)	52	(3)	45	(32)	14	(2)	31	(2)	144	(3)
5th to 94th Percentile	239	(78)	1,273	(74)	1,060	(73)	468	(73)	1,263	(74)	4,303	(75)
≥95th percentile	53	(17)	366	(21)	309	(21)	142	(22)	384	(22)	1,254	(22)
Unknown	0		8	(<1)	2	(<1)	0	(<1)	1	(<1)	11	(<1)
<i>Gaps in primary care†</i>												
No gaps	170	(58)	785	(46)	670	(47)	270	(43)	737	(44)	2,632	(46)
Up to half the time	31	(11)	601	(35)	520	(37)	211	(34)	648	(39)	2,011	(35)
More than half the time	93	(32)	313	(18)	226	(16)	143	(23)	294	(18)	1,069	(19)

† A gap in primary care was defined as less than 2 office visits for any reason within 2 years.

* Reported at time of entry into the study cohort.

was often a marker for children who were severely affected by co-morbidities. A separate regression model limited to the subgroup of subjects with severe asthma revealed an association between obesity (BMI ≥ 95th percentile) and

hospitalization (Table 3). An association of low BMI and outcome in this subgroup could not be estimated reliably due to the limited number of children with this combination of severity and BMI.

Table 2. Effects of care processes on hospitalization rates.

Parameter	Value	IRR	95% CI	p
Two visits or more in preceding 24 months	Present		reference	
	Absent	1.39	1.09–1.78	0.008
Inhaled steroids	Present		reference	
	Absent	0.81	0.65–1.01	0.058
Asthma control tool	Present		reference	
	Absent	0.87	0.72–1.06	0.18
	No opportunity*	1.26	0.72–2.21	> 0.2
Asthma care plan	Present		reference	
	Absent	0.73	0.60–0.88	0.001
Community Asthma Prevention Program	Present		reference	
	Absent	0.64	0.47–0.87	0.005
Spirometry	Present		reference	
	Absent	0.81	0.63–1.04	0.097
	No opportunity**	0.81	0.38–1.70	> 0.2
Influenza	Vaccinated		Reference	
	Unvaccinated	0.86	0.71–1.04	0.12
	Not in season	1.09	0.94–1.27	> 0.2

* No opportunity for asthma control tool: tool not yet implemented in system.

** No opportunity for Spirometry: patient was too young.

Table 3. Effects of asthma severity and co-morbidities on hospitalization.

Cohort	Co-morbidity	IRR	95% CI	p
Non-severe asthma	Normal weight	Reference		
	Low BMI	2.15	1.35—3.43	0.001
	Obesity	0.98	0.77—1.25	>0.2
Severe asthma	Normal weight	Reference		
	Low BMI*	0.18	0.05—0.63	0.007
	Obesity	2.05	1.01—4.17	0.047

*There were only 3 subjects with BMI < 5% in the severe asthma subgroup. Together, these subjects only experienced 1 hospitalization, so the rate ratio cannot be reliably calculated.

Discussion

This study examines the transitions from primary outpatient care to inpatient care at the level of individual patients over a 5-year observation period. Asthma is often considered an “ambulatory care sensitive condition,” meaning that hospitalization for asthma may often be avoidable [21,22]. However, population-based studies have not identified modifiable health-care processes that reduce asthma hospitalization rates. In this cohort of 5,712 children with asthma, commonly used indicators of high quality outpatient asthma care were not associated with fewer hospitalizations for asthma. The only statistically significant factor associated with fewer hospitalizations was regular access to primary care.

Consistent access to primary care has been shown to decrease rates of ED utilization and hospitalization [23–25]. Lack of outpatient primary care (no more than one primary care visit in any 24-month period), a pre-specified factor of interest in our study, emerged as a modifiable factor that was associated with asthma hospitalizations. Asthma patients with well-controlled symptoms are recommended to be seen at least every 6 months to review asthma symptoms and the treatment plan. However, in urban settings such as ours, health care is often fragmented across multiple settings, and it may be difficult to ensure timely access to the recommended preventive health-care and chronic disease management services. Access to health care can be limited by insurance status, and we found some evidence of a higher risk of asthma hospitalization among the uninsured. It may be that the subgroup of families who consistently access care also are predisposed to being attentive to daily health needs such as taking preventive medications and being vigilant for the early signs of an asthma flare reducing the frequency of asthma flares and hospitalizations. Given that to some extent regular access to health care likely motivates improved disease management behaviors in the home, our results indicate that interventions to increase access to primary health care for children with asthma may decrease their risk for future asthma hospitalizations.

Among patient-level factors, having a BMI below the 5th percentile was associated with higher asthma hospitalization risk among the cohort of subjects with non-severe asthma. Chart review revealed that many of these subjects also had other co-morbidities that, when severe, could affect both growth and asthma hospitalization risk. These co-morbidities may also serve as co-factors that increases risk of hospitalization that is primarily attributed to asthma. Among children with severe asthma, we found that those who were also obese (BMI ≥ 95th percentile) were at a higher risk of hospitalization, which is in line with findings of prior research exploring the relationship between obesity and asthma exacerbations [26–28]. Obesity is a challenging target for intervention, but it does present a potentially modifiable factor that may reduce asthma hospitalization risk.

A pay for performance initiative designed to improve asthma care processes was introduced during the observation period at 4 of 5 participating sites. However, the adjusted hospitalization rate was only observed to decline prior to the introduction of this initiative; therefore, no beneficial effect of pay for performance was observed. These incentives did not reward efforts to improve the access to care for children with asthma.

Race was not associated with hospitalization risk in the multivariable results, though others have shown this association [2,29–31]. The confidence intervals for these negative results within specific age and gender subgroups were often large due to small numbers of non-African American subjects. With adequate sample sizes, future analyses could help identify how race may interact with clinical, process, and structural factors that influence outcomes in asthma care.

Limitations

Although this study involved a single institution, the observed hospitalization rate (64 hospitalizations per 1,000 children per year) falls between the overall rates estimated for predominantly African American children with asthma in the US (37 hospitalizations per 1,000 children per year), and other high-risk urban minority populations (130 hospitalizations per 1,000 children per year) [32,33]. Our findings about the association of several modifiable exposures and the rate of hospitalization likely do not reflect unusual baseline risks in the population studied. The age of the data available for this analysis (from 2004 to 2008) is an additional limitation. However, these results are likely still applicable because there have been no major changes in management recommendations and no new asthma medications have been developed for routine use in primary care during the intervening period.

The fact that typically beneficial interventions such as ACPs and CAPP referrals were associated with increased risk of asthma-related hospitalizations suggests that the standard four levels of asthma severity employed in clinical guidelines were insufficient to adequately adjust risk—residual confounding by indication was likely still present. For example, among children with moderate-persistent asthma there is likely a wide spectrum of baseline risk that may range from a level similar to that of the children with mild-persistent asthma up to a risk similar to those with severe-persistent asthma. Correctly estimating the effect of these interventions on hospitalization rate in retrospective analysis requires more granular and accurate measures for categorizing disease severity such as asthma symptom scores and treatment intensity required to obtain good symptom control [34,35]. For risk adjustment purposes in evaluations of healthcare quality, methods for categorizing disease severity may be required beyond those employed in clinical guidelines.

Our analysis relied on an EHR that should, if properly implemented, contain all data necessary for our proposed analysis. The absence of documented severity among 15% of the subjects necessitated imputation of this key clinical factor. Until clinicians use EHRs in a manner that captures all clinically relevant data for both individual patient care and for the evaluation of care across populations of patients, retrospective studies relying on medical records, even those based on the latest computerized databases, face challenges. Finally, comparisons of asthma hospitalization rate by race and ethnicity were not possible because most of the subjects (96%) in this inner city population were African American, and there were only 39 subjects (<1%) of Hispanic origin.

Conclusions

In this cohort of 5,712 predominantly African American children with asthma, commonly used indicators of high quality outpatient asthma care were not associated with fewer hospitalizations for asthma. The only factor associated with fewer hospitalizations was regular access to primary care. Future studies should prospectively evaluate the impact of improved access to care on asthma-related hospitalizations.

Acknowledgments

The authors thank the network of primary care physicians, their patients, and families for their contribution to clinical research through the Pediatric Research Consortium (PeRC) at CHOP. They also thank Cayce Hughes for his assistance in drafting the manuscript.

Declaration of interest

The authors report no conflict of interest.

Funding

This research was funded by the Agency for Healthcare Research and Quality (contract number HHSA-290-2007-10013 Task Order 2, Rockville, MD).

ORCID

Levon H. Utidjian  <http://orcid.org/0000-0002-2189-108X>

References

1. Akinbami LJ, Moorman JE, Liu X. Asthma prevalence, health care use, and mortality: United States, 2005–2009. National Health Statistics Reports. Hyattsville, MD; 2011 Jan. Report No.: 32.
2. Akinbami LJ, Moorman JE, Bailey C, Zahn HS, King M, Johnson CA, Liu X. Trends in asthma prevalence, health care use, and mortality in the United States, 2001–2010. NCHS data brief. Hyattsville, MD; 2012 May. Report No.: 94.
3. Bedouch P, Sadatsafavi M, Marra CA, FitzGerald JM, Lynd LD. Trends in asthma-related direct medical costs from 2002 to 2007 in British Columbia, Canada: a population based-cohort study. PLoS ONE 2012;7(12):e50949.
4. Gershon AS, Guan J, Wang C, To T. Trends in Asthma Prevalence and Incidence in Ontario, Canada, 1996–2005: A Population Study. Am J Epidemiol 2010;172(6):728–736.
5. Newacheck PW, Halfon N. Prevalence, impact, and trends in childhood disability due to asthma. Arch Pediatr Adolesc Med 2000;154(3):287–293.
6. Pediatric Quality Indicators Technical Specifications—Version 5.0, March 2015 [Internet]. qualityindicators.ahrq.gov. [cited 2015 Jul 12]. Available from: http://www.qualityindicators.ahrq.gov/Modules/PDI_TechSpec.aspx
7. National Heart Lung and Blood Institute, National Asthma Education and Prevention Program. Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma [Internet]. National Institutes of Health; 2007. Available from: <http://www.nhlbi.nih.gov/files/docs/guidelines/asthgdln.pdf>
8. Lieu TA, Quesenberry CP, Capra AM, Sorel ME, Martin KE, Mendoza GR. Outpatient management practices associated with reduced risk of pediatric asthma hospitalization and emergency department visits. Pediatrics 1997;100 (3 Pt 1):334–341.
9. Lukacs SL, France EK, Barón AE, Crane LA. Effectiveness of an asthma management program for pediatric members of a large health maintenance organization. Arch Pediatr Adolesc Med. 2002;156(9):872–876.
10. Rust G, Zhang S, Reynolds J. Inhaled corticosteroid adherence and emergency department utilization among Medicaid-enrolled children with asthma. J Asthma. 2013;50(7):769–775.

11. Mandel KE, Kotagal UR. Pay for performance alone cannot drive quality. *Arch Pediatr Adolesc Med. Am Med Assoc* 2007;161(7):650–655.
12. Johnson RM, Johnson T, Zimmerman SD, Marsh GM, Garcia-Dominic O. Outcomes of a seven practice pilot in a pay-for-performance (P4P)-based program in Pennsylvania. *J Racial Ethn Health Disparities* 2015;2(1):139–148.
13. Coffin SE, Zaoutis TE, Rosenquist ABW, Heydon K, Herrera G, Bridges CB, Watson B, Localio R, Hodinka RL, Keren R. Incidence, complications, and risk factors for prolonged stay in children hospitalized with community-acquired influenza. *Pediatrics* 2007;119(4):740–748.
14. Herman-Giddens ME, Slora EJ, Wasserman RC, Bourdony CJ, Bhapkar MV, Koch GG, Hasemeier CM. Secondary sexual characteristics and menses in young girls seen in office practice: a study from the Pediatric Research in Office Settings network. *Pediatrics* 1997;99(4):505–512.
15. Neinstein LS. Adolescent health care: a practical guide. Philadelphia, PA: Lippincott Williams & Wilkins; 2008.
16. Donahue JG, Fuhlbrigge AL, Finkelstein JA, Fagan J, Livingston JM, Lozano P, Platt R, Weiss ST, Weiss KB. Asthma pharmacotherapy and utilization by children in 3 managed care organizations. *J Allergy Clin Immunol* 2000;106(6):1108–1114.
17. van Buuren S. Multiple imputation of discrete and continuous data by fully conditional specification. *Stat Methods Med Res* 2007;16(3):219–242.
18. Christakis DA, Mell L, Koepsell TD, Zimmerman FJ, Connell FA. Association of lower continuity of care with greater risk of emergency department use and hospitalization in children. *Pediatrics* 2001;107(3):524–529.
19. Rubin DB. Multiple imputation for nonresponse in surveys. Hoboken, NJ: Wiley-Interscience; 2004.
20. National Center for Health Statistics. Current Asthma Population Estimates, By Age, United States, National Health Interview Survey, 2014 [Internet]. Hyattsville, MD; 2016 [cited 2016 Nov 15]. Available from: <http://www.cdc.gov/asthma/nhis/2014/table 3-1.htm>
21. Billings J, Zeitel L, Lukomnik J, Carey TS, Blank AE, Newman L. Impact of socioeconomic status on hospital use in New York City. *Health Affairs* 1993;12(1):162–173.
22. Rosano A, Loha CA, Falvo R, van der Zee J, Ricciardi W, Guasticchi G, de Belvis AG. The relationship between avoidable hospitalization and accessibility to primary care: a systematic review. *Eur J Public Health* 2013;23(3):356–360.
23. Cree M, Bell NR, Johnson D, Carriere KC. Increased continuity of care associated with decreased hospital care and emergency department visits for patients with asthma. *Dis Manage* 2006;9(1):63–71.
24. Auger KA, Kahn RS, Davis MM, Beck AF, Simmons JM. Medical home quality and readmission risk for children hospitalized with asthma exacerbations. *Pediatrics* 2013;131(1):64–70.
25. Huang S-T, Wu S-C, Hung Y-N, Lin I-P. Effects of continuity of care on emergency department utilization in children with asthma. *Am J Manage Care* 2016;22(1):e31–e37.
26. Vargas PA, Perry TT, Robles E, Jo C-H, Simpson PM, Magee JM, Feild CR, Hakkak R, Carroll PA, Jones SM. Relationship of body mass index with asthma indicators in Head Start children. *Ann Allergy, Asthma Immunol* 2007;99(1):22–28.
27. Mosen DM, Schatz M, Magid DJ, Camargo CA Jr. The relationship between obesity and asthma severity and control in adults. *J Allergy Clin Immunol* 2008;122(3):507–511.e6.
28. Quinto KB, Zuraw BL, Poon K-YT, Chen W, Schatz M, Christiansen SC. The association of obesity and asthma severity and control in children. *J Allergy Clin Immunol* 2011;128(5):964–969.
29. Everage NJ, Pearlman DN, Sutton N, Goldman D. Disparities by race/ethnicity and sex: asthma hospitalizations and emergency department visit rates in Rhode Island and Healthy People 2010 goals. *Med Health R I* 2010;93(6):177–8–181–3.
30. Roy SR, McGinty EE, Hayes SC, Zhang L. Regional and racial disparities in asthma hospitalizations in Mississippi. *J Allergy Clin Immunol* 2010;125(3):636–642.
31. Akinbami LJ, Moorman JE, Simon AE, Schoendorf KC. Trends in racial disparities for asthma outcomes among children 0 to 17 sources, 2001–2010. *J Allergy Clin Immunol* 2014;134(3):547–553.e5.
32. Akinbami LJ, Moorman JE, Garbe PL, Sondik EJ. Status of Childhood Asthma in the United States, 1980–2007. *Pediatrics* 2009;123(Supplement):S131–S145.
33. Webber MP, Hoxie A-ME, Odlum M, Oruwariye T, Lo Y, Appel D. Impact of asthma intervention in two elementary school-based health centers in the bronx, New York City. *Pediatr Pulmonol* 2005;40(6):487–493.
34. Reddel HK, Taylor DR, Bateman ED, Boulet L-P, Boushey HA, Busse WW, Casale TB, Chanez P, Enright PL, Gibson PG, de Jongste JC, Kerstjens HAM, Lazarus SC, Levy ML, O'Byrne PM, Partridge MR, Pavord ID, Sears MR, Sterk PJ, Stolf SW, Sullivan SD, Szeffler SJ, Thomas MD, Wenzel SE. an official american thoracic society/european respiratory society statement: asthma control and exacerbations. *Am J Respir Crit Care Med*. 2009 Jul;180(1):59–99.
35. Taylor DR, Bateman ED, Boulet L-P, Boushey HA, Busse WW, Casale TB, Chanez P, Enright PL, Gibson PG, de Jongste JC, Kerstjens HAM, Lazarus SC, Levy ML, O'Byrne PM, Partridge MR, Pavord ID, Sears MR, Sterk PJ, Stolf SW, Szeffler SJ, Sullivan SD, Thomas MD, Wenzel SE, Reddel HK. A new perspective on concepts of asthma severity and control. *Eur Respir J* 2008;32(3):545–554.