Correlation of Care Process Measures With Childhood Asthma Exacerbations

WHAT’S KNOWN ON THIS SUBJECT: Asthma is a common focus of pediatric quality improvement efforts. Various processes of care have been postulated as markers of high-quality pediatric asthma care, but it is not clear which processes correlate with a lower risk of asthma exacerbations.

WHAT THIS STUDY ADDS: This study analyzed the correlation of processes of care identifiable through administrative data with asthma exacerbations. The use of 0 vs ≥ 1 controller medications and the asthma medication ratio had the strongest correlation with asthma exacerbations.

abstract

OBJECTIVE: We sought to define processes of pediatric asthma care identifiable through administrative data that correlate with asthma exacerbations for use in quality improvement.

METHODS: Commercially insured children aged 5 to 17 years from the Pediatric Physicians’ Organization at Children’s, an independent practice association affiliated with Boston Children’s Hospital, with persistent asthma in 2008, 2009, or 2010 were identified. The correlations of various process measures with asthma exacerbations, defined as hospitalizations or emergency department visits for asthma or outpatient visits for asthma with an oral steroid prescription, were analyzed by using logistic regression.

RESULTS: Significant correlations were found between filling 0 vs ≥ 1 controller medications in all years (relative risk [RR] 3.35, 2.11, and 2.71 in 2008, 2009, and 2010, respectively) although only 4% of subjects overall filled no controller medications. The asthma medication ratio (controller prescriptions divided by total asthma prescriptions) was also associated with exacerbations, with the lowest 2 quartiles having a lower risk compared with the highest in all years (RR 2.27, 2.45, and 2.39 for the lowest; RR 2.10, 2.02, and 2.65 for the second quartile in 2008, 2009, and 2010, respectively).

CONCLUSIONS: Filling 0 vs ≥ 1 controllers and the asthma medication ratio correlated with asthma exacerbations. Although both might serve as quality improvement metrics for pediatric asthma, we favor the asthma medication ratio because it applies to a broader range of children with asthma and better reflects the recommended clinical approach for children with persistent asthma. Pediatrics 2013;131:1–8

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KEY WORDS
asthma, quality improvement

ABBREVIATIONS
CI—confidence interval
ED—emergency department
HEDIS—Healthcare Effectiveness Data and Information Set
ICS—inhaled corticosteroid
LTRA—leukotriene receptor antagonist
QI—quality improvement
RR—relative risk
SABA—short-acting β agonist

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Asthma is one of the most common chronic diseases of childhood, estimated to affect 10% of US children, and is therefore an important focus of pediatric quality improvement (QI) programs. As with other chronic diseases, the implementation of effective QI programming in asthma relies in part on identifying process measures that correlate with improved health outcomes. One clearly desirable outcome for patients with asthma is a reduction in the occurrence of acute exacerbations requiring medical attention, because such exacerbations signal poor asthma control. Identifying process measures of asthma care definable through administrative data that correlate with fewer exacerbations would help health care organizations and clinicians focus efforts on interventions likely to enhance patients’ health and, conversely, not spend limited time and resources on processes that do not affect outcomes.

To better define effective processes of care among children with asthma, we analyzed medical and pharmacy claims data from a large cohort of patients of the Pediatric Physicians’ Organization at Children’s, an independent practice association of 72 private pediatric practices in eastern Massachusetts affiliated with Boston Children’s Hospital. We sought to correlate various process measures for asthma care that were available through administrative data with the occurrence of exacerbations requiring medical attention. Process measures used in the analysis were chosen based on the available literature and included the receipt of seasonal influenza vaccine, the number of nonexacerbation outpatient asthma visits, and various measures of prescription medication use patterns.

METHODS

Children aged 5 to 17 years who met Healthcare Effectiveness Data and Information System Set (HEDIS) criteria for persistent asthma in calendar years 2008, 2009, and/or 2010 were selected by using paid medical claims from all patients of the Pediatric Physicians’ Organization at Children’s Hospital insured by a single large not-for-profit insurer.

Asthma exacerbations were defined as paid medical claims meeting any of the following criteria: (1) a hospitalization with a primary diagnosis of asthma (International Classification of Diseases, Ninth Revision codes 493.xx); (2) an emergency department (ED) visit with a primary diagnosis of asthma; or (3) an outpatient visit with a primary or secondary diagnosis of asthma and an oral steroid prescription filled the day of or the day after the visit. To assess the correlation of asthma exacerbations with these process measures, we created a series of logistic regression models with the occurrence of ≥1 asthma exacerbations within the year as the dependent variable and each proposed process measure as the independent variable, with adjustment for subjects’ gender and age. The process measures considered were as follows: (1) receipt of the seasonal influenza vaccine; (2) the number of nonexacerbation asthma visits; (3) the number of controller prescriptions filled (0 vs ≥1, ≥75% of the year vs 50%–75% of the year vs <50% of the year, and quartiles); (4) the type of controller medications filled; (5) the number of short-acting β agonist (SABA) prescriptions filled (quartiles); and (6) the ratio of controller prescriptions filled to total asthma prescriptions filled (≥0.5 vs <0.5, and quartiles). Prescription fills were counted as defined in HEDIS specifications. For oral medications, each prescription fill for a supply of ≤30 days was counted as 1 prescription fill; prescriptions filled with a days’ supply of 31 through 60 days were counted as 2 prescription fills, and so on. For inhaled medications, each filling event was counted as a single prescription fill irrespective of the days’ supply specified.

This project met our institution’s definition of QI and was therefore exempt from institutional review board review.

RESULTS

In 2008, 528 of 19 469 continuously enrolled patients aged 5 to 17 years (2.7%) met HEDIS criteria for persistent asthma; the corresponding figures for 2009 and 2010 were 505/19 778 (2.6%) and 529/20 230 (2.6%), respectively. In 2008, 180 asthma exacerbations requiring medical attention occurred; 15 (8.3%) were hospital admissions, 60 (33.3%) ED visits, and 105 (58.3%) outpatient visits with an oral corticosteroid prescribed. In 2009, there were 184 exacerbations of which 17 (9.2%) were admissions, 55 (29.9%) ED visits, and 112 (60.9%) outpatient visits with an oral corticosteroid prescribed. In 2010, there were 169 exacerbations, of which 16 (9.5%) were admissions, 39 (23.1%) ED visits, and 114 (67.5%) outpatient visits with an oral corticosteroid prescribed. The number and proportion of subjects experiencing ≥1 exacerbations within the calendar year were 174 (33.0%) in 2008, 166 (32.9%) in 2009, and 178 (33.6%) in 2010.

The results of logistic regression modeling the correlation between the various potential process measures and asthma exacerbations are shown in Table 1 (for unadjusted risk ratios, see Supplemental Table 2). There was no correlation between receipt of the annual seasonal influenza vaccine and exacerbations. There was a significant association between the number of nonexacerbation asthma visits and exacerbations in 2009 only, although the same trend was present in all 3 years (namely, that subjects with fewer nonexacerbation visits had a lower risk of having ≥1 exacerbations within the year).
In terms of controller medications, there was a significant association in all years between exacerbations and filling 0 controller prescriptions versus ≥1 (relative risk [RR] 3.35, 95% confidence interval [CI] 2.24–5.00 in 2008; RR 2.11, 95% CI 1.24–3.58 in 2009; RR 2.71, 95% CI 1.70–4.31 in 2010). There was no association in any of the years between asthma exacerbations and the proportion of the year covered by controller prescriptions. We also evaluated the association between quartiles of the number of controller prescriptions filled and exacerbations (quartiles for 2008: 0–3, 4–6, 7–10, and ≥11; quartiles for 2009 and 2010: 0–2, 3–5, 6–9, and ≥10). We found no associations except for the lowest quartile compared with the highest in 2009 (RR 1.61, 95% CI 1.02–2.55) and 2010 (RR 1.86, 95% CI 1.15–3.01). The type of controller medications filled (inhaled corticosteroid [ICS] versus leukotriene receptor antagonists [LTRA] versus both) was somewhat associated with exacerbations. There was a statistically lower risk of asthma exacerbations in those subjects filling LTRA alone in 2009 (RR 0.06, 95% CI 0.01–0.44) and a trend in the same direction in 2008 and 2010, although the association did not meet statistical significance in those 2 years.

The number of SABA prescriptions filled within the year did not correlate strongly with asthma exacerbation, except for an association between those filing ≥4 vs 0 or 1 in 2008 (RR 1.94, 95% CI 1.33–2.84) and in 2009 (RR 2.05, 95% CI 1.34–3.12). The controller-to-total medication ratio was consistently associated with exacerbations. Subjects with a ratio of <0.5 had a higher risk of exacerbations in 2009 and 2010 (RRs 1.67 and 1.62, respectively) and those in the lowest 2 quartiles of the ratio had a lower risk compared with those in the highest quartiles in all years (RR of 2.27, 2.45, and 2.39 for the lowest quartile in 2008, 2009, and 2010, respectively; RR of 2.10, 2.02, and 2.65 for the second quartile versus the highest quartile in 2008, 2009, and 2010, respectively).

To better understand the association of exacerbations with the controller-to-total medication ratio, we examined the risk of ≥1 exacerbations in the year within quartiles. As shown in Fig 1, the proportion of subjects having an exacerbation generally declined with increasing quartiles of controller-to-total ratio, from 25.0% to 24.2%, 17.1%, and 11.5% in 2008; the corresponding proportions for 2009 and 2010 were 26.0%, 21.4%, 24.4%, and 10.7% for 2009 and 23.5%, 28.3%, 15.9%, and 9.9% for 2010.

To better understand the relationship between the type of controller medications filled and the risk of having ≥1 asthma exacerbations, we examined the number of prescription fills per year for subjects using ICS only (n = 535) compared with those using LTRA only within a given year (n = 249). There was a statistically higher median number of yearly prescription fills for controller medications among subjects using LTRA versus those using ICS (7 vs 3, respectively, P < .001; Fig 2). Conversely, there was a lower median number of SABA prescriptions filled per year by subjects using LTRA versus those using ICS (1 vs 2, respectively; P < .0001).

**DISCUSSION**

In this study examining the use of administrative data to identify process measures that correlate with asthma exacerbations, we found that filling 0 vs ≥1 controller medications and the asthma medication ratio (number of controller prescriptions filled divided by total number of asthma prescriptions filled) both correlated strongly with asthma exacerbations. Although either of these 2 metrics could be used as a process measure for pediatric asthma care, they may serve somewhat different purposes. The use of 0 vs ≥1 controller medications identifies a small number of patients who have not filled any controller prescriptions and are thus at increased risk of exacerbation, but this population is small, representing 4% of subjects in our sample. In contrast, the asthma medication ratio identifies a larger population of children at risk for exacerbation and emphasizes the importance of regular controller medication use in persistent asthma, which is consistent with national recommendations and with an appropriate educational message for patients with asthma.

In analyzing the asthma medication ratio further, we found the strongest protective effect against asthma exacerbations in the highest and next-to-highest quartiles. In our network for the years, the highest quartile consisted of subjects with ratios of >0.9 or higher (ie, 90% of all asthma prescriptions filled being controllers), whereas the next quartile consisted of subjects with ratios of ~0.75 to 0.9 (ie, 75%–90% of all asthma prescriptions being controllers). These levels of asthma medication ratio are somewhat higher than those that have been reported in national data: for example, from the Medical Expenditure Panel Survey from 2005 and 2006, which reported 73.8% of adults and pediatric subjects having a ratio of >0.5 compared with 82.6% in our data. It is also important to note that using a cutoff asthma medication ratio of ≥0.5, as is proposed as a possible HEDIS measure, did not perform as well as a higher ratio would in our data. Clinically, it stands to reason that a ratio of near 0.5 is not representative of high-quality asthma care that a patient with persistent asthma who fills 1 or nearly 1 SABA prescription for every controller prescription is not likely to be adequately controlled; such a patient would almost certainly qualify to step-up controller therapy according to best practice recommendations. The 1 possible exception to this reasoning...
| TABLE 1 Risk of Having ≥1 Asthma Exacerbations Within the Calendar Year for Various Asthma Process Measures, Adjusted for Age and Gender |
|---|---|---|
| **Seasonal influenza vaccine** | **Type of controller** | **Exacerbation** |
| 2008 (n = 528) | 2009 (n = 505) | 2010 (n = 528) |
| n (%) With ≥1 Exacerbation | RR (95% CI), Adjusted for Age and Gender | n (%) With ≥1 Exacerbation | RR (95% CI), Adjusted for Age and Gender | n (%) With ≥1 Exacerbation | RR (95% CI), Adjusted for Age and Gender |
| **Yes** | 72/340 (21.2) | Reference | 76/340 (22.4) | Reference | 80/372 (21.5) | Reference |
| **No** | 38/188 (20.2) | 0.95 (0.67–1.35) | 31/185 (16.8) | 0.83 (0.57–1.21) | 28/157 (18.5) | 0.87 (0.59–1.29) |
| **Nonexacerbation asthma office visits** | **Controller prescriptions, ≥1 vs 0 (HEDIS 2012)** | **Controller prescriptions, % of year covered (HEDIS 2012)** |
| ≥2 | 65/277 (22.7) | Reference | 76/284 (26.8) | Reference | 80/300 (26.7) | Reference |
| 1 | 26/149 (17.5) | 0.79 (0.53–1.19) | 19/133 (14.3) | 0.53 (0.34–0.85)* | 17/163 (10.4) | 0.41 (0.25–0.68)* |
| 0 | 21/102 (20.6) | 0.97 (0.62–1.50) | 12/88 (13.6) | 0.51 (0.29–0.90)* | 12/66 (18.2) | 0.69 (0.40–1.19) |
| **Controller prescriptions, ≥1 vs 0 (HEDIS 2012)** | **Number of controller prescriptions filed** | **Number of SABA prescriptions, quartiles** |
| ≥75% but <75% | 16/106 (15.1) | 0.82 (0.48–1.40) | 20/103 (19.4) | 1.01 (0.62–1.64) | 19/97 (19.5) | 0.95 (0.59–1.53) |
| <50% | 44/192 (22.9) | 1.24 (0.85–1.82) | 47/208 (22.6) | 1.16 (0.79–1.68) | 45/234 (18.4) | 0.91 (0.62–1.35) |
| **No controller prescriptions filled** | **Type of controller** | **Controller to total medication ratio (proposed HEDIS)** |
| 9/9 (100.0) | Reference | 8/18 (44.4) | 2.11 (1.24–3.58)* | 11/24 (45.8) | 2.71 (1.70–4.31)* |
| **Highest** | 27/140 (19.3) | Reference | 26/138 (18.8) | Reference | 21/130 (16.2) | Reference |
| 3rd | 18/108 (16.7) | 0.90 (0.52–1.54) | 23/119 (19.3) | 1.03 (0.62–1.70) | 22/114 (19.3) | 1.23 (0.72–2.12) |
| 2nd | 25/122 (20.5) | 1.10 (0.68–1.79) | 28/148 (18.9) | 1.00 (0.62–1.61) | 29/154 (18.8) | 1.16 (0.69–1.94) |
| Lowest | 40/158 (25.3) | 1.39 (0.91–2.14) | 30/100 (30.0) | 1.61 (1.02–2.55)* | 37/131 (28.2) | 1.86 (1.15–3.01)* |
| **Type of controller** | **Both** | **Controller to total treatment ratio** |
| ICS | 24/131 (18.3) | Reference | 42/188 (22.3) | Reference | 40/216 (18.5) | Reference |
| LTRA | 8/89 (9.0) | 0.52 (0.25–1.09) | 17/65 (26.2) | 0.60 (0.01–0.44)* | 10/84 (11.9) | 0.72 (0.37–1.40) |
| **Both** | 65/287 (22.7) | 1.21 (0.80–1.83) | 56/223 (25.1) | 1.15 (0.81–1.62) | 48/205 (23.4) | 1.26 (0.87–1.84) |
| **No controllers** | 13/21 (61.9) | Reference | 8/18 (44.4) | Reference | 11/24 (45.8) | Reference |
| **Number of SABA prescriptions, quartiles** | **Controller to total medication ratio, quartiles** | **Controller to total medication ratio, quartiles** |
| ≤1 | 42/231 (18.2) | Reference | 30/187 (16.0) | Reference | 29/192 (15.1) | Reference |
| 2 | 21/117 (17.9) | 0.99 (0.62–1.58) | 29/128 (22.5) | 1.41 (0.89–2.23) | 31/130 (23.8) | 1.54 (0.98–2.41) |
| 3 | 13/85 (15.3) | 0.83 (0.46–1.47) | 13/84 (15.5) | 0.97 (0.54–1.75) | 22/87 (25.3) | 1.62 (0.98–2.65) |
| ≥4 | 34/95 (35.8) | 1.94 (1.33–2.84)* | 35/105 (33.3) | 2.05 (1.34–3.12)* | 27/120 (22.5) | 1.49 (0.93–2.38) |
| **Controller to total medication ratio, quartiles** | **Controller to total medication ratio, quartiles** | **Controller to total medication ratio, quartiles** |
| ≤0.5 | 84/452 (18.6) | Reference | 79/421 (18.8) | Reference | 73/417 (17.5) | Reference |
| <0.5 | 17/87 (25.4) | 1.42 (0.91–2.22) | 25/81 (30.9) | 1.67 (1.14–2.46)* | 27/103 (26.2) | 1.62 (1.10–2.38)* |
| **Not calculable (no prescription fills)** | **Not calculable (no prescription fills)** | **Not calculable (no prescription fills)** |
| 9/9 (100.0) | Reference | 3/3 (100.0) | Reference | 9/9 (100.0) | Reference |

*RRs significant at the P < .05 level.

applies to children who use SABA only for pretreatment of exercise-induced bronchospasm, absent other symptoms of persistent asthma. We expect that few such subjects would have been included in our analysis because most children with only exercise-induced bronchospasm do not meet HEDIS criteria for persistent asthma. However, insofar as such subjects were included in our analysis, children with frequent exercise-induced bronchospasm and concomitant frequent SABA use may be better served by regular use of controller medications.13,15 Despite this caveat, based on our data as well as our clinical sense, an asthma medication target ratio of 0.75 or 0.8 would be preferable for an
organization seeking optimal care for children with persistent asthma.

In contrast to the asthma medication ratio, we did not find the number of controller prescriptions filled, measured as the proportion of the year covered or as quartiles, to be consistently associated with exacerbation risk. This is an important finding because one of the current HEDIS asthma quality measures, “Medication Management for People With Asthma” considers what proportion of eligible patients filled sufficient controller prescriptions to cover 50% and 75% of the year. Based on our data, this measure does not accurately capture processes associated with exacerbation risk. Our hypothesis for why the asthma medication ratio predicts exacerbation risk better than the number of controllers is based on the wide range of severity of children who meet HEDIS criteria for persistent asthma. Some of these children have relatively mild and episodic asthma and may not need controllers on a daily basis but also do not use much rescue mediation and thus have a low controller number for the year but an acceptable ratio. We suspect that in a cohort of more severe asthmatic patients who truly need controller treatment on a daily basis to remain healthy, the controller number would likely perform better as a predictor of exacerbations. We also suspect that some providers are recommending intermittent use of controllers only during high-risk periods for children on the milder end of the persistent asthma spectrum, perhaps based on recent evidence that intermittent controller use may be effective for such children.\textsuperscript{16,17} If intermittent controller use is indeed effective in selected cases, it would result in lower compliance with the current HEDIS measures that rely on controller number but would presumably result in acceptable asthma medication ratios as long as SABA use is sparing.

Another interesting finding from our data is the risk of exacerbation according to the type of controller medications used. Subjects using LTRA alone had a trend toward fewer exacerbations than those using ICS alone. This result may be seen as surprising because in most head-to-head randomized trials, ICS controller has proven to be more effective than LTRAs in children with persistent asthma.\textsuperscript{18–23} There are 2 possible explanations for our finding to the contrary. First, because our study was not a randomized trial, it is possible that subjects treated with LTRA had less severe asthma than those treated with ICS. This possibility is supported by the fact that the median number of SABA prescriptions filled per year was higher in the ICS-treated patients than in the
LTRA-treated subjects. A second possible explanation is that subjects prescribed LTRA were more adherent with their controller treatment than those prescribed ICS. Our data are also consistent with this second hypothesis in that subjects treated with LTRA had significantly more controller fills per year than those prescribed ICS, by a large margin (a median of 7 fills per year vs 3). This hypothesis is also supported by a recent pragmatic practice-based randomized trial in adults and adolescents that showed LTRA to be equivalent to ICS for persistent asthma control largely because of better adherence to LTRA therapy.\textsuperscript{24,25} This raises an interesting dilemma for clinicians and health care organizations as to whether ICS, a more biologically efficacious treatment, or LTRA, an apparently more acceptable treatment to patients, should be recommended. This dilemma may present an opportunity for shared decision-making between clinician and patient/family.\textsuperscript{26,27}

It is perhaps not surprising that receipt of seasonal influenza vaccine was not associated with a lower risk of asthma exacerbations in our study, for 2 reasons. First, studies in this area have not demonstrated a consistently protective effect of the vaccine against asthma exacerbations\textsuperscript{4,28–30}; variable factors such as the proximity of the antigen match in a given year may be important factors in the vaccine’s effectiveness. Second, children with more severe asthma would presumably be more likely to receive seasonal influenza vaccine, therefore biasing our result toward a null finding.\textsuperscript{4} At any rate, the specific effectiveness of seasonal influenza vaccine for children with asthma is somewhat of an academic point because seasonal influenza vaccine is currently recommended for all children aged 6 months to 18 years.

In terms of exacerbation risk, according to the number of nonexacerbation asthma office visits, we hypothesized that more frequent visits (presumably for asthma education and to review treatment plans, etc) might correlate with fewer exacerbations, but we found a trend toward the opposite effect. We suspect this finding reflects the fact that children whose asthma is under poor control may be brought in to the office more frequently than those in good control, and thus a higher number of nonexacerbation office visits might be a marker for less well-controlled asthma and would not be useful as a metric of high-quality care.

This work has 3 primary limitations. First, the results apply to privately insured children aged 5 to 17 years who meet HEDIS criteria for persistent asthma; they may not apply equally to children younger than 5 years, those with public insurance, or those who have intermittent asthma. Second, our
models relied solely on administrative data available from health plan claims. Such claims are well known to suffer from certain limitations, and the addition of clinical data from electronic medical records, chart reviews, and patient/family surveys could enhance further analyses of risk factors for pediatric asthma exacerbations. However, the goal of our project was to define risk factors specifically identifiable through claims data that could be useful for QI programs, which frequently rely on claims data as the major source of measurement. Third, there are specific limitations to the interpretation of prescription fill data. Filling a prescription does not necessarily equate to using all (or indeed any) of the medication, although repeated fills of the same medication suggest regular use. In addition, the counting of medication fills is somewhat arbitrary, especially for inhaled medications; according to the referenced methodology, a metered dose inhaler canister of fluticasone contains 200 inhalations, whereas a dry powder canister of fluticasone contains 60 inhalations. Such limitations in quantifying inhaled medication use may introduce minor inaccuracies into models such as ours, but this approach still represents the most accurate available method by using administrative claims data alone; additional refinements of medication use data would require chart review or direct medication use monitoring.

CONCLUSIONS
We found both filling 0 vs ≥1 controller prescriptions in a year and the asthma medication ratio (number of prescription fills of controller medications divided by number of prescription fills of all asthma medications) to be the process measures available from administrative data that correlate best with asthma exacerbations among children with persistent asthma. Although either of these processes might serve as QI metrics for pediatric asthma care, we favor the asthma medication ratio because it applies to a broader range of children with asthma and better reflects the current recommended approach to care for children with persistent asthma. Additional work in this area that involves supplementing administrative data with additional key pieces of clinical data, perhaps available from structured elements of electronic medical records, may help to define modifiable aspects of care delivery that predict even more strongly which children with asthma are at high risk for exacerbations.

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