Asthma Medication Use and Disease Burden in Children in a Primary Care Population

Paula Lozano, MD, MPH; Jonathan A. Finkelstein, MD, MPH; Julia Hecht, PhD; Reeva Shulruff, MD; Kevin B. Weiss, MD

Background: Children with persistent asthma underuse controller medications and overuse relievers. A better understanding of the appropriateness of regimens, medication adherence, and adequacy of asthma control is needed.

Objectives: To describe use of asthma medications and disease burden in children with persistent asthma, to determine whether use of controllers and relievers is consistent with national guidelines, and to estimate adequacy of asthma control.

Design: Cross-sectional cohort study.

Setting: Forty-two primary care practices participating in 3 regions of the United States.

Participants: Parents of 638 children aged 3 to 15 years with asthma.

Main Outcomes Measures: Asthma symptom–days, use of reliever and controller medications, and adequacy of asthma control, ascertained by face-to-face questionnaire.

Results: The mean age was 9.4 years, and 59.9% were boys. In the preceding 2 weeks, two thirds (67.5%) of subjects had 0 to 4 symptom-days, 15.8% had 5 to 9 symptom-days, and 16.6% had 10 to 14 symptom-days (percentages do not total 100 because of rounding). One third (32.6%) of children using relievers had high levels of use. One third (34.3%) of children using controllers used them 4 or fewer days per week. Among children with some evidence of persistent disease (use of controllers, excess symptoms, or excess reliever use), almost two thirds (64.3%) were inadequately controlled. This group consisted both of children reportedly using controllers less than recommended and those reporting not receiving controller medication at all.

Conclusions: In this insured population, inappropriate reliance on relievers and nonadherence to controllers were common. Inadequate asthma control was common regardless of whether controllers were prescribed.


THE BURDEN of asthma on children is substantial.1-3 Daily use of inhaled anti-inflammatory agents reduces airway obstruction and clinical symptoms in persons with persistent asthma symptoms4-8 and is associated with reduced hospitalizations9 and mortality.10 Although decreased growth velocity has been detected (primarily in prepubertal children and those receiving higher doses of inhaled corticosteroids11,12), it may be transient13 and without reduction in attained adult height.16,17

The National Asthma Education and Prevention Program’s18,19 1997 guidelines, the Expert Panel Report 2 (EPR-2), recommend inhaled anti-inflammatory medication (controllers) for persistent asthma symptoms to reduce reliance on inhaled β-agonists (relievers), defining persistent asthma according to symptoms and peak flow. The choice of drug and dosage depends on asthma severity. The National Committee for Quality Assurance20 developed a quality-of-care measure based on dispensing of controllers to persons with persistent asthma and has incorporated this measure in its Health Plan Employer Data and Information Set assessment.

Although controller use has increased in recent years, overreliance on reliever medication continues to be common, and frequency and duration of controller use fall short of recommendations.21-27 Many studies are hampered by the lack of symptom data, which are required for accurate assessment of medication regimen appropriateness. In the present study, we assessed whether use of controllers and relievers is consistent with...
the EPR-2 guidelines among children with differing levels of symptoms.

We analyzed parent-reported asthma medication use and symptoms in this population of insured children to: (1) estimate the frequency of inappropriate medication-taking behavior, including overuse of relievers and inconsistent controller use; (2) estimate adequacy of asthma control, defined by medication use and symptoms; and (3) determine whether inadequate asthma control is associated with demographic characteristics or concurrently reported processes of asthma care. We hypothesized that older age, nonwhite ethnicity, household poverty, not having seen a specialist, and not having a written care plan would be associated with a greater proportion of inadequate control.

**METHODS**

**SETTING AND STUDY POPULATION**

This cross-sectional study used baseline data from the 638 patients enrolled in the Pediatric Asthma Care Patient Outcomes Research Team II (PAC-PORT). The PAC-PORT is a multicenter randomized trial of asthma care improvement strategies in 42 practices in 3 geographic locales: 15 western Washington State practices affiliated with Group Health Cooperative; 11 Chicago practices affiliated with Rush-Prudential Health Systems; and 16 network practices in eastern Massachusetts, each affiliated with several health insurers, including Harvard Pilgrim Health Care and Blue Cross and Blue Shield of Massachusetts.

Potential subjects were identified by searching automated claims and pharmacy data for 1 year for children aged 3 to 15 years having an asthma-related claim for a hospitalization, emergency department visit, or ambulatory encounter. If the only asthma claim was for an ambulatory encounter, we also required the child to have received 2 or more asthma medications during the same period. This algorithm identified 7052 children. We succeeded in contacting parents of 5286 (75.0%) of these children by telephone for further screening for eligibility. The telephone screen identified children who used daily medications for 2 months or longer for 1 year as eligible and excluded those with severe asthma or another major chronic illness. The goal of this 2-stage screening process was to identify children with mild persistent or moderate persistent asthma, without serious comorbid conditions. Of those contacted, 42.5% refused to undergo telephone screening, 38.6% were ineligible, and 18.9% (1000 children) were eligible. Between August 1, 1997, and October 31, 1998, parents of 638 of the eligible children (63.8% of all those eligible) participated in baseline interviews. Approval was obtained from the institutional review board at each study site.

**VARIABLES**

**Demographics**

Demographic variables included age, racial/ethnic group, and household income. The child was considered to be “nonwhite” if the parent chose any ethnic category other than “white/Caucasian” (ie, black/African American, Asian/Pacific Islander, American Indian/Native American, Spanish/Hispanic, or other). We coded children as living in poverty if their household income was at or below 200% of the federal poverty level for their size household.

**Medication Classes**

Controllers consisted of cromolyn sodium, nedocromil sodium, inhaled corticosteroids, and theophylline. (Few subjects reported theophylline use.) The use of leukotriene receptor inhibitors and salmeterol xinafoate was negligible. Relievers consisted of inhaled bronchodilators. For each class of medication, parents were asked if the child ever used medications in this class and, if so, how frequently he or she had used it in the past 4 weeks. In this article, we describe children’s medication use during the preceding 4 weeks in terms of current regimen, medication-taking frequency, reliever dosing, and controller dosing.

**Reliever Dosing**

Reliever dosing in the preceding 4 weeks was categorized as low (metered-dose inhaler use ≤2 days per week or 3-4 days per week [≤5 puffs per day] or nebulizer use ≤4 days per week) or high (metered-dose inhaler use 3-4 days per week [≥5 puffs per day] or ≥5 days per week or nebulizer use ≥5 days per week). This definition of high reliever use was designed to include children taking albuterol sulfate in response to persistent asthma symptoms (using EPR-2 criteria), while minimizing the number of children taking albuterol before exercise.

**Controller Dosing**

Controller dosing in the preceding 4 weeks was considered to be appropriate if the parent reported inhaled corticosteroid use or cromolyn or nedocromil use 5 or more days per week. Underdosed was defined as inhaled corticosteroid or cromolyn or nedocromil use 4 or fewer days per week. A child using both classes of controllers was considered to be appropriately dosed if he or she met criteria for appropriateness in either class. Information on the prescribed number of doses per day was not available. Our definition of appropriate dosing was liberal in that we did not consider the number of inhalations and we classified children based solely on the number of days per week of reported medication use.

**Asthma Symptom–Days in the Past 2 Weeks and “Excess Asthma Symptoms or Reliever Use”**

Asthma symptom–days in the past 2 weeks were determined by ascertaining the number of days in the preceding 2 weeks during which the child had any asthma symptoms, including cough, wheeze, or limitation in activity.28,29 We converted the EPR-2’s daytime symptom criteria for persistent symptoms to a 2-week time frame (>2 days per week roughly equals ≥4 days in 2 weeks) to identify children with excess asthma symptoms. Children with 3 to 14 symptom-days or high reliever use were considered to have “excess asthma symptoms or reliever use.” The only children not considered to have excess symptoms or reliever use were those with 0 to 4 symptom-days and low or no reliever use. Not included in this measure were peak flow (data not collected) and nights per month of nocturnal symptoms (because of the absence of a validated tool and our desire to minimize false-positive results).

**Adequacy of Control**

To characterize the adequacy of asthma control, the study population was divided into 4 groups according to current regimen (no controller vs controller) and excess symptoms or reliever use (no vs yes). Children without excess symptoms or reliever use and on a current regimen that included controllers were
considered to be adequately controlled on controller medication. Children on any regimen who had excess symptoms or reliever use were considered to be inadequately controlled. The proportion with inadequate control was defined as a fraction in which the numerator was the number of children with inadequate control and the denominator was the sum of the numbers of adequately controlled and inadequately controlled children. Subjects in whom there was no evidence of need for controller medication (no controller in current regimen and no excess symptoms or reliever use) were excluded from this calculation.

Processes of Asthma Care

We examined 2 processes of asthma care: specialist visit (in the past 6 months) and individualized written care plan (ever received, used in the past year, and reviewed or revised in the past 6 months). Parents were asked about any health care use for asthma in the past year, including outpatient visits (scheduled and unscheduled), emergency department visits, and hospitalizations.

STATISTICAL ANALYSIS

Categorical variables were analyzed using the χ² test and, when appropriate, the χ² test for trend. The association between adequacy of asthma control and demographic and process-of-care characteristics was assessed using the χ² test and multivariate regression analysis. We used one multivariate logistic regression model to determine the demographic variables associated with adequacy of asthma control. All demographic variables significant at P<.10 were included in all subsequent models. Separate logistic regression models were used to assess associations between process-of-care variables and adequacy of asthma control. The full model was generated by including all demographic and process-of-care variables that met the criterion of P<.10. For inferences, we considered associations with P<.05 to be statistically significant.

RESULTS

SAMPLE DEMOGRAPHICS

Characteristics of the 638 children with asthma whose parents completed interviews are given in Table 1. The mean age of subjects was 9.4 years, and 59.9% were boys. Eighty-four children (13.2%) lived in households with incomes at or below 200% of the federal poverty level. Parent-identified ethnic groups were 65.9% white, 17.4% black, 5.3% Hispanic, 2.8% Asian/Pacific Islander, 0.8% American Indian, and 7.8% other.

ASTHMA BURDEN AND SERVICES RECEIVED

The subjects had a mean of 4.1 days of asthma symptoms in the past 2 weeks and 7.4 days of asthma medication use in the same period (Table 1). About two thirds (67.5%) of children had 0 to 4 symptom-days, 15.8% had 5 to 9 symptom-days, and 16.6% had 10 to 14 symptom-days (percentages do not total 100 because of rounding). Children with 5 to 9 symptom-days met National Asthma Education and Prevention Program criteria for mild persistent asthma; those with 10 to 14 symptom-days met criteria for moderate or severe persistent disease. Most children (64.9%) had made at least 1 health care visit for asthma in the past year. In the past year, 22.9% of subjects had made a visit to the emergency department for asthma and 3.8% had been hospitalized for asthma. One fifth (21.5%) of the children were reported to have ever received a written care plan, and 13.6% had seen a specialist in the past 6 months.

ASTHMA REGIMENS AND HIGH RELIEVER DOSING

The most common (45.9%) current asthma regimen (in the past 4 weeks) among all ages was reliever plus controllers. Children with 5 or more symptom-days (who would qualify as having persistent asthma) constituted a substantial proportion of the reliever plus controller and the reliever-only groups (42.1% and 37.3%, respectively) but only 11.2% and 2.0% of the no-medications groups (42.1% and 37.3%, respectively) but only 11.2% and 2.0% of the no-medications and controller-only groups, respectively.

One third (32.6%) of parents reported high reliever dosing (3–4 days per week [≥5 puffs per day] or ≥5 days per week). High reliever dosing was increasingly common with age: 19.6% among preschoolers, 31.5% among school-age children (6–11 years), and 41.1% among teens (12–15 years) (P=.001).

USE OF CONTROLLER MEDICATIONS

About three quarters (73.4%) of children had used controller medications at some time. Interestingly, lifetime history of controller use was more common with younger

---

**Table 1. Sample Characteristics and Asthma Disease Burden**

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Value (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD), y</td>
<td>9.4 (3.5)</td>
</tr>
<tr>
<td>Male, No. (%)</td>
<td>382 (59.9)</td>
</tr>
<tr>
<td>Nonwhite ethnicity, No. (%)</td>
<td>211 (33.1)</td>
</tr>
<tr>
<td>Household poverty, No. (%)</td>
<td>94 (12.2)</td>
</tr>
<tr>
<td>Asthma effect, mean (SD)</td>
<td></td>
</tr>
<tr>
<td>Asthma symptom−days in past 14 d, mean (SD)</td>
<td>4.13 (4.69)</td>
</tr>
<tr>
<td>Asthma medication−days in past 14 d, mean (SD)</td>
<td>7.37 (6.03)</td>
</tr>
<tr>
<td>School days missed because of asthma in the past 2 mo (n = 307), mean (SD)</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>138 (45.0)</td>
</tr>
<tr>
<td>1−2</td>
<td>99 (32.2)</td>
</tr>
<tr>
<td>≥3</td>
<td>70 (22.8)</td>
</tr>
<tr>
<td>Use of health services for asthma, No. (%)</td>
<td></td>
</tr>
<tr>
<td>Any physician visit for asthma in past year</td>
<td>414 (64.9)</td>
</tr>
<tr>
<td>Emergency department visit for asthma in past year</td>
<td>146 (22.9)</td>
</tr>
<tr>
<td>Asthma hospitalization in past year</td>
<td>24 (3.8)</td>
</tr>
<tr>
<td>Seen specialist for asthma in past 6 mo</td>
<td>87 (13.6)</td>
</tr>
<tr>
<td>Ever received written care plan</td>
<td>137 (21.5)</td>
</tr>
<tr>
<td>Current asthma regimen in past 4 weeks, No. (%)†</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>101 (15.8)</td>
</tr>
<tr>
<td>Reliever medication only</td>
<td>182 (28.5)</td>
</tr>
<tr>
<td>Controller medication only</td>
<td>57 (9.8)</td>
</tr>
<tr>
<td>Reliever + controller</td>
<td>293 (45.9)</td>
</tr>
</tbody>
</table>

†N = 638. Only items with at least 95% complete data are reported for all variables except school days missed in the past 2 months. If the 2-month window included vacation, this item was coded as missing. Therefore, this variable is reported for a denominator of 307.

*Controllers consist of cromolyn sodium, nedocromil sodium, inhaled corticosteroids, and theophylline. (The use of leukotriene receptor inhibitors and salmeterol xinafoate was negligible.) Relievers consist of inhaled bronchodilators.
age: 80.4% among preschoolers, 75.7% among school-age children, and 65.3% among teens ($P = .003$) (Table 2). This trend was related to greater lifetime use of cromolyn and nedocromil in the younger age groups. Prevalence of ever having used cromolyn or nedocromil was 53.9%, 41.4%, and 35.2% among preschoolers, school-age children, and teens, respectively ($P = .003$). There was no significant age trend for lifetime use of inhaled corticosteroids.

Current users of controller medications represented 54.9% of all children. Current controller use was similar in children with 1 to 4 and 5 to 14 symptom-days (60.2% and 61.4%, respectively) but lower (40.7%) in children with zero symptom-days (Figure). Controller underdosing was most common in school-age children (37.9%) and least common in preschool children (19.3%). Controller underdosing was most common in children with 1 to 4 symptom-days (37.9%) and least common in those with zero symptom-days (23.4%). When grouped according to use of reliever medications, the highest rate of controller underuse (51.8%) was found in children with low reliever use, whereas similar rates were found in the subsets with no (17.7%) or high (18.5%) reliever use.

ADEQUACY OF CONTROL

There were 175 children (27.7%) with no evidence of need for controller medication and another 163 (25.8%) who were apparently well controlled (no excess symptoms or reliever use) using controller medications (Table 4). Two groups appeared to be inadequately controlled: 108 (17.1%) had excess symptoms or reliever use in the absence of controller medication, and 186 (29.4%) had excess symptoms or reliever use while receiving some controller medication. The proportion of inadequately controlled children (computed by dividing the number of inadequately controlled [cells b and d] children by the total number of children with any evidence of active disease [cells b, c, and d]) was 64.3%. We excluded from the denominator children who were not using controller medication and had no excess symptoms or reliever use, because we wished
to consider only the subset with evidence of a need for controller medication. Three demographic characteristics—age, nonwhite ethnicity, and household poverty—were significantly (or borderline significantly) associated with an increased proportion of inadequate control in bivariate analyses (data not shown) and in a multivariate logistic regression model that included all demographic variables (Table 5). Neither sex nor study site showed significant association with adequacy of control. The 3 variables pertaining to written care plans showed a trend toward a protective effect but did not achieve statistical significance (Table 5). The complete model, which included site, age, nonwhite ethnicity, household poverty, written care plan (ever received), and specialist care, largely confirmed these findings (Table 5). Having seen a specialist in the past 6 months was significantly associated with a lower likelihood of inadequate asthma control (odds ratio, 0.51; 95% confidence interval, 0.30-0.87). For the same association, the odds ratio for household poverty was 1.96 (95% confidence interval, 1.03-3.70) and for nonwhite ethnicity, 1.17 (95% confidence interval, 1.00-1.37).

### COMMENT

**MAJOR FINDINGS**

This sample of insured children with mild to moderate persistent asthma experienced considerable burden due to asthma. Inappropriate reliance on relievers and insufficient use of controllers were common. Underdosing of controller medications by patients was common across the range of symptom-days; thus, children with the most to gain from improved asthma control were among those frequently underusing controller medications. Inadequate asthma control was common and included children taking and not taking controller medication (17.1% and 29.4% of the total sample, respectively). Younger age and having seen an asthma specialist were associated with more adequately controlled asthma.
CONTEXT

Compared with recent studies,20,25 our sample shows comparable levels of asthma symptom–burden, including asthma symptom–days in the past 2 weeks and controller underuse. National and maintenance care organization (MCO)–based surveys23,25,26 and analyses of administrative data31,32 have found that as many as two thirds of adults with persistent asthma underused inhaled anti-inflammatory medications. Only 55% of children with persistent asthma in managed care reported using long-term control medication daily.25 Studies34,35 in urban populations found that only a quarter to one half of children with high-risk asthma reported daily anti-inflammatory medication use.

In addition to demonstrating rates of controller use comparable to those of other published reports, we assessed the degree to which the child’s asthma symptoms were being controlled by examining concurrent reliever use and symptoms. (A similar measure of asthma control was found to correlate with quality of life and health care use.38,39) By dividing the sample according to asthma control as well as by use or nonuse of controllers (Table 4), we identified 2 subsets: those with poor control using no controller medication and those with poor control receiving insufficient controller medication. To the extent that inadequate control is a function of undertreatment, the delineation of these 2 groups of inadequately controlled children suggests that efforts to improve asthma care should focus not only on initiation of controller therapy but also on optimizing the dose and assisting patients with medication adherence. Both groups, of course, might benefit to an unknown extent from mitigation of environmental triggers. The proportion of the population in each of these subsets and the overall proportion of subjects with inadequate control may serve as feasible and useful outcome measures for clinical quality improvement efforts and merit further study.

Compared with younger children, teens were least likely to have ever received a controller medication and (in multivariate models) most likely to experience inadequate asthma control. These findings are consistent with the lower likelihood of teens filling a first controller prescription and continuing controller therapy for 5 or more prescriptions that was found previously in the MCOs participating in the PAC-PORT50 and in an earlier study24 conducted at one of the MCOs. This highlights the need for a better understanding of factors affecting adherence in teens and for interventions aimed at improving teen adherence.

According to parent report, children in the youngest age group (ages 3-5 years) were the most likely to have ever received controller medication, resulting from greater cromolyn use at younger ages (Table 2). Levels of current controller use in our sample were comparable to those found in the larger population of all children with asthma enrolled in these MCOs,52 but whereas the larger asthma population showed lower use of controllers in the youngest age group, we found current controller use was similar across age groups, possibly reflecting differences in the study populations. Parent report of a health care provider diagnosis of asthma was required for entry into the present study. Because health care providers may be reluctant to diagnose asthma in younger children, this criterion may have disproportionately excluded preschoolers who might have had wheezing associated with upper respiratory tract infections that was treated with albuterol.

Children living in poverty and those of nonwhite ethnicity were more likely to experience inadequate asthma control in this managed care population, a finding that echoes the results of studies41-43 in other settings. However, the association between poverty or ethnicity and inadequacy of care only achieved borderline significance in the multivariate model containing both variables.

Multivariate analyses failed to find an association between written care plans and adequacy of control. Although written instructions may assist parents in adjusting medications during an exacerbation and may thus prevent an acute visit,49 care plans as used did not appear to have an effect on day-to-day asthma control. The association of adequacy of asthma control with specialty care has been noted by others.25,26 Although the cross-sectional study design limits the interpretation of this association, it suggests that the 13.6% of children in our sample who had seen an allergist or pulmonologist in the preceding 6 months experienced care that promoted use of controller medications, and raises the question of whether key processes of care could be made more widely available to all children with asthma. The randomized trial conducted as part of the PAC-PORT was designed to answer this question.

The underuse of controller medication seen in this study is likely a result of many factors. Several barriers may limit the appropriate use of controllers by health care providers: difficulties in identifying children with persistent symptoms, confusion in selecting an appropriate medication, lack of information on the correct dose and duration, concerns about adverse effects of corticosteroids (including growth delay), and frustration with patient nonadherence. A survey of physicians in the PAC-PORT MCOs found that concerns about adverse effects were common.49 Patient nonadherence to prescribed controller regimens is also common46,47 and may be related to fears about adverse effects,48,49 misunderstanding about the need for daily dosing,50 lack of immediate symptom relief (leading to the perception of ineffectiveness), and technical difficulties of inhaler administration.46

LIMITATIONS

We excluded children whose asthma was very mild, very severe, or managed primarily by an asthma specialist, somewhat limiting the generalizability of our findings to these patients. Although our refusal rate was high, it is not unusual for clinical trials (of which this cross-sectional study was a part). Among children who were screened and found to be eligible, refusers did not differ substantively from study subjects. Our definition of inadequately controlled asthma was based only on asthma symptom–days and level of β-agonist use (using criteria derived from the EPR-2 severity classification) and did not incorporate monthly frequency of nocturnal symp-
Conclusions  

In this insured population, inappropriate reliance on relievers, insufficient use of controllers in children with persistent symptoms, and overall inadequate asthma control were common and may contribute to the substantial burden of asthma in children.

Accepted for publication September 5, 2002.

From the Center for Health Studies, Group Health Cooperative, Seattle, Wash (Drs Lozano and Hecht); Department of Pediatrics, University of Washington, Seattle (Dr Lozano); Departments of Ambulatory Care and Prevention and Pediatrics, Harvard Medical School, and Harvard Pilgrim Health Care, Boston, Mass (Dr Finkelstein); Rush-Presbyterian Health Systems, Chicago, Ill (Dr Shulruff); Midwest Center for Health Services and Policy Research, Hines VA Hospital, Hines, Ill; and Center for Healthcare Studies and Division of General Medicine, Department of Medicine, Northwestern University Feinberg School of Medicine, Chicago (Dr Weiss).

What This Study Adds

Prescribing of controller medication in many populations falls short of national asthma guidelines. Prior studies have not fully described controller use in the context of symptoms.

In this study of 638 children with mild to moderate persistent asthma in 3 MCOs, among children whose parents reported current use of controller medication, only two thirds actually took the medications 5 or more days per week. Nonadherence was common across subgroups with varying symptom frequencies. We used parent report of asthma symptoms and frequency of reliever medication to assess adequacy of asthma control. Although one third of children with inadequate control were not using controllers, two thirds reported some controller use, suggesting that increasing the prescribed or delivered dose may improve asthma control in this subset.

We thank Kelly Arduino, MA, Nancy Laranjo, MA, Cynthia Sisk, Lisa Wasson, and Joanne Fagan, RN, for coordinating data collection and management; Vincent Carey, PhD, and Bill Barlow, PhD, for their statistical expertise; and Anne Fuhlbrigge, MD, MPH, Sean Sullivan, PharmD, PhD, Tom Inui, MD, MPH, and Ed Wagner, MD, MPH, for their thoughtful comments on study design and presentation of data. We thank the families who participated in this study in Chicago, Boston, and Seattle. The PACHEPORT II is funded by grant HS08368-01 from the Agency for Healthcare Research and Quality, Rockville, Md, and the National Heart, Lung, and Blood Institute, Bethesda, Md.

Corresponding author and reprints: Paula Lozano, MD, MPH, Center for Health Studies, Group Health Cooperative, 1730 Minor Ave, Suite 1600, Seattle, WA 98101 (e-mail: plozano@u.washington.edu).

REFERENCES