# Identifying high-risk asthma with utilization data: a revised HEDIS definition

**Antonia V. Bennett, MA**[1], **Paula Lozano, MD**[2,4], **Laura P. Richardson, MD**[2,5], **Elizabeth McCauley, PhD**[3,5], and **Wayne Katon, MD**[3]

1 *Department of Health Services, University of Washington School of Public Health, Seattle, WA*

2 *Department of Pediatrics, University of Washington School of Medicine, Seattle, WA*

3 *Department of Psychiatry & Behavioral Sciences, University of Washington School of Medicine, Seattle, WA*

4 *Center for Health Studies, Group Health Cooperative, Seattle WA*

5 *Children's Hospital and Regional Medical Center, Seattle WA*

## Abstract

**Objective**—To develop a definition of high-risk asthma based on a single year of patient utilization data that will, compared to the 2006 HEDIS definition, more precisely identify patients needing case management.

**Study Design**—Two-year claims based study, with cross-sectional phone survey data, for a sample of 769 youth (ages 11−17) with asthma.

**Methods**—The 2006 HEDIS measure defines high-risk asthma as meeting any of the following criteria: ≥1 emergency department visits, or ≥1 hospitalizations for asthma, or ≥4 asthma medication prescriptions, or ≥4 ambulatory visits for asthma with ≥2 prescriptions for asthma medication in one year. We created a revised definition of high-risk asthma ( ≥1 emergency department visits or ≥1 hospitalizations for asthma or ≥1 oral steroid prescriptions for asthma) and identified patients with high-risk asthma in Year 1 according to each definition. We compared the two groups with respect to demographic and clinical characteristics, health care utilization and costs in Years 1 and 2.

**Results**—The revised definition identified 29% of the sample to have high-risk asthma whereas the 2006 definition identified 67%. Compared to the 2006 definition, the revised definition identified patients with significantly greater asthma-related physical health problems and higher medical costs in Year 1. In Year 2, youth classified as high-risk by the revised definition made more emergency department visits and were more likely to use oral steroids than those classified as high-risk by the 2006 definition.

**Conclusions**—The revised high-risk asthma definition identifies half as many individuals and is better able to identify patients with poorly controlled asthma in the subsequent year.

### Keywords

Asthma; Case management; Health outcomes; Pediatrics; Risk management/assessment

**Corresponding Author:** Antonia V. Bennett, MA Doctoral Student University of Washington Department of Health Services, Box 357660 Seattle, WA 98105−7660 Phone: 206-524−0584 Fax: 206-543−3964 E-mail: abenn@u.washington.edu.

# INTRODUCTION

Asthma is the most common chronic illness of childhood and adolescence, and in many individuals persists into adulthood, causing functional impairment and resulting in considerable use of health services[1-4]. Randomized controlled trials have shown asthma disease management programs to be effective[5-8] and some organized health care systems have integrated disease management systems into their process of care. The resources directed towards disease management can be optimized by targeting youth with the highest risk of adverse consequences. A method for identifying these youth based solely on administrative data would be valuable for health plans [9, 10].

The Health Plan Employer Data and Information Set (HEDIS) definition of high-risk asthma is one method used to identify patients through administrative data. Figure 1 shows the 2006 HEDIS definition and the revised definition proposed in this study. There is evidence to suggest the 2006 HEDIS definition resulted in high levels of misclassification[11, 12]. A prior study found the definition to be overly broad because two criteria (four or more prescriptions for asthma medication and four or more ambulatory visits for asthma plus two prescriptions) resulted in including large numbers of youth and may represent patients adhering to and doing well with care[12].

The HEDIS definition of high-risk asthma was amended in 2007 in order to reduce the amount of misclassification. The 2007 definition requires patients to meet at least one of the utilization criteria in a 12-month period *for two consecutive 12-month periods* and the criteria met in each period do not need to be the same ones. Although the extended time period increases the fidelity of the HEDIS definition, the 24-month period would limit the definition's utility as a case-finding tool. A definition of high-risk asthma that requires only 12-months of utilization data, instead of 24-months, would enable health plans to identify patients needing disease management in a time frame that would be amenable to preventive interventions.

This paper describes the development of a revised definition that identifies patients with asthma who are at risk for adverse outcomes, using 12-months of utilization data. The revised definition proposed in this paper is similar to the 2006 definition in that only 12-months of utilization data are required but the criteria are changed. We removed two above-mentioned criteria (four or more prescriptions for asthma medication and four or more ambulatory visits for asthma plus two prescriptions), hypothesizing that youth who met these criteria alone as a group were not at high-risk for adverse outcomes. The criterion of 'one or more oral steroid prescriptions for asthma' was added to capture youth requiring treatment for significant exacerbations. In this study we tested the revised definition against the 2006 HEDIS definition to determine if one is more suitable for identifying high-risk patients. Compared to the 2006 HEDIS definition, we hypothesized the revised definition would capture fewer of the youth with well-controlled persistent asthma and fewer of the youth with intermittent asthma.

# METHODS

## Study population

The data for this study were collected as part of the Stress and Asthma Research (STAR) study, a cross-sectional survey study of depression and anxiety among youth with asthma[13]. Potential subjects for the STAR study were youth (11 to 17 years of age) with asthma who were enrolled in a Group Health Cooperative insurance plan for at least 6 months. Group Health Cooperative (GHC) is a nonprofit health maintenance organization with 25 primary care clinics in Washington State owned by GHC as well as 75 contracted clinics. Youth with asthma were identified through the GHC automated cost and utilization database system by at least one of the following types of utilization:

a. At least one hospitalization in the past year with an asthma diagnosis and had at least one asthma prescription during the that year;

b. At least one emergency department or urgent care visit in the past year with an asthma diagnosis and had at least one asthma prescription during that year;

c. At least two office visits in the past year with an asthma diagnosis and had at least one asthma prescription during that year;

d. At least one visit in the past year with an asthma diagnosis and another in the past 18 months and had at least one asthma prescription;

e. Only 1 asthma visit in the past year but at least two asthma prescriptions filled on different days in that year;

f. At least four prescriptions for asthma medication in the past year.

These criteria were developed to identify youth with active asthma and screen out patients with very mild asthma (such as mild exercise-induced asthma) and youth with spurious asthma diagnoses (i.e. wheezing secondary to acute respiratory infection). All youth meeting inclusion criteria were invited to participate in the STAR study. Participants of the STAR study with cost and utilization data were included in this analysis. All participants gave informed consent. The study protocols were reviewed and approved by the institutional review board of GHC.

### Data collection

Following receipt of a letter inviting participation in the STAR study, subjects were screened by telephone interview which included a 10 to 15 minute parent interview and a 45- to 75-minute youth interview. The parent interview included confirmation that their child had been diagnosed with asthma, the number of years since diagnosis with asthma, and demographic questions.

**Demographic information—**Child age and sex was determined from administrative data and confirmed during parent interview. The family's address and zip code were linked to census data to determine the median household income of their census block group. Enrollment in Medicaid or the Washington State Basic Health Plan was identified though administrative data.

**Asthma experience and health status indicators—**Asthma symptom days, or the number of days with asthma symptoms in the prior two weeks, was used as a proxy for asthma severity[14]. Based on the National Asthma Education and Prevention Program (NAEPP) guidelines, 0−4 symptom days is considered to be equivalent to intermittent to mild persistent asthma and 5−14 symptom days is considered persistent asthma[15]. The youth's experience with asthma was identified in the phone interview using the Child Health Survey – Asthma (CHS-A). The CHS-A is a functional status measure with high reliability and validity in capturing a broad range of asthma experiences. Three of the instrument subscales are included in this analysis -- physical health, activity limitations, and emotional health, which are scored from 0 to 100 with higher scores indicating better outcomes[16]. The Pediatric Chronic Disease Score (PCDS) is an algorithm drawing on claims data for prescription fills that classifies children into chronic disease categories[17]. The modified version of the PCDS used in the STAR study did not include medications used primarily for asthma, anxiety or depression. Higher scores on the modified PCDS indicate greater non-asthma-related medical morbidity

**Cost and utilization—**Cost and utilization data were taken from the GHC computerized cost and utilization database system for the twelve month period preceding baseline (Year 1) and the twelve month period following baseline (Year 2). This system uses general ledger costs to calculate actual budget-based cost (not charges) for all services provided or purchased by

Group Health Cooperative. Total health services costs include costs for all conditions including asthma.

### Analysis

High-risk status according to the 2006 HEDIS and revised definitions was determined based on individual utilization in Year 1 according to the criteria shown in Figure 1. We examined the number of youth identified by individual criteria in order to compare the relative contributions of each criterion. Descriptive statistics were used to evaluate the revised definition of high-risk asthma, first, by comparing the characteristics of high-risk youth to low-risk youth identified within each definition, and second, by comparing the characteristics of the high-risk youth identified by each definition. Differences between the high-risk and low-risk groups within each definition were evaluated by t-tests for groups with unequal variance and Pearson's Chi-squared tests. Differences between the high-risk groups of each definition were also compared by t-tests for groups with unequal variance and Pearson's Chi-squared tests. For all tests a p-value of less than 0.05 was considered significant. The characteristics examined are youth and parent demographics, health characteristics including asthma symptom days, and health services costs and utilization in Year 1 and Year 2. The analysis was conducted using Stata v8.0 [18].

## RESULTS

Of the 1458 youth and parents in the initial sample, 170 were ineligible leaving an eligible sample of 1288. Reasons for ineligibility included: child did not have asthma (n=63), disenrolled from GHC (n=84), language ineligibility (n=11), parent too ill (n=6) and other (n=6). Of the eligible sample, 833 parents gave consent and permission for the study to contact their child with asthma. From these 833, the study obtained child consent and completed 781 interviews for a final recruitment rate of 60.6%. The final sample that this analysis will be based on is 769 youth (12 youth or their parent did not give permission for the use of cost and utilization data). Full details of the sample are published elsewhere [19].

### Sample characteristics, costs and utilization

The demographic and health characteristics of the total sample are described in Table 1. The 2006 HEDIS definition classified 518 (67%) as high-risk, whereas the revised definition classified only 223 (29%) as high-risk. All youth classified as high-risk by the revised definition were also classified as high-risk by the 2006 HEDIS definition. The total health care costs and utilization related to asthma of the total sample are described in Table 3. For the total sample (N=769) total health care costs were $2,759 in Year 1 and $2,503 in Year 2.

### Criterion and step-wise comparison of high-risk definitions

Table 2 reports the number of youth identified by each individual criterion. The definitions were also examined in a step-wise manner and the cumulative number of youth identified with each additional criterion is reported for each definition. Nine youth (1.2%) had inpatient hospitalizations, and 65 youth (8.5%) had inpatient hospitalizations or emergency department visits. The addition of the revised definition criterion 'one or more prescriptions for oral steroids' identified a total of 223 youth (29.0%). In contrast, the addition of the HEDIS criterion 'four or more prescriptions for asthma' identifies a total of 514 youth (66.8%) and the fourth HEDIS criterion 'four or more ambulatory visits and two or more prescriptions for asthma' captures an additional four youth, for a total of 518 (67.4%). The 2006 HEDIS definition identified 295 youth as high-risk that the revised definition did not identify; these 295 youth had no asthma-related hospitalizations, emergency department visits, or prescriptions for oral steroids.

### Demographic and health characteristics by risk group

The 2006 HEDIS definition identified a high-risk group that was very similar to the 2006 HEDIS definition low-risk group in demographic and health plan characteristics (Table 1). In contrast, the revised definition identified a high-risk group that was older and had lower parental educational attainment compared to the low-risk group. Both definitions identified high-risk groups with greater morbidity compared to the respective low-risk groups. The high-risk group for *either* definition had higher mean Pediatric Chronic Disease Scores, had been diagnosed with asthma approximately one year earlier, had more days of asthma symptoms in the prior two weeks and slightly lower CHS-A emotional health scores than the low-risk group. There were no differences between groups in the CHS-A activity limitation scores.

The only statistically significant difference *between* the two high-risk groups was in self-reported asthma-related physical limitations, indicated by the CHS-A physical health score, which was worse for the revised definition high-risk group compared to the 2006 HEDIS definition high-risk group. The revised definition high-risk group reported more symptom days than the HEDIS definition high-risk group, but this difference was not statistically significant.

### Cost and utilization of health services by risk group

Cost and utilization of health services for each group, in years one and two, are presented in Table 3 and described below.

**2006 HEDIS definition high-risk versus low-risk youth—**There was no difference in Year 1 total health services costs between the 2006 HEDIS high-risk and low-risk groups, however Year 2 total health services costs were higher for the high-risk group than the low-risk group. Utilization of all types (inpatient hospitalizations for asthma, emergency department and ambulatory visits for asthma, and for prescriptions for asthma medication) in both Year 1 and Year 2 was higher for the 2006 HEDIS definition high-risk group than the low-risk group.

**Revised definition high-risk versus low-risk youth—**Total health services costs in both Year 1 and Year 2 were higher for the revised definition high-risk group compared to the low-risk group. The high-risk group had higher utilization of all types in Year 1 and also higher utilization of all types in Year 2 except for inpatient hospitalizations compared to the low-risk group.

**Comparison of high-risk youth according to the two definitions—**The revised definition high-risk group had higher Year 1 total health services costs than the 2006 HEDIS high-risk group. Year 2 total health services costs, were $600 higher for the revised definition high-risk group compared to the 2006 HEDIS definition high-risk group but were not statistically different. Youth in the revised definition high-risk group made more emergency department visits and outpatient visits, and were more likely to have used any oral steroids for asthma in Year 1, compared to the 2006 HEDIS definition high-risk group. In Year 2, youth in the revised definition high-risk group made more emergency department visits and were more likely to have used any oral steroids for asthma compared to the 2006 HEDIS definition high-risk group.

## DISCUSSION

In this article we propose a more efficient model for identifying youth for asthma case management. This new definition is more precise: it identifies about half as many youth as the 2006 HEDIS definition for high-risk asthma and unlike the 2007 definition only requires one rather than two years of health plan data. The youth identified as high-risk by the revised definition have significantly more asthma-related physical limitations and higher costs in Year

1 compared to youth identified with the 2006 HEDIS definition. Furthermore, youth identified as high-risk by the revised definition compared to youth identified as high-risk by the 2006 HEDIS definition have greater asthma morbidity in the subsequent year, including a higher number of emergency department visits, a higher percentage treated with oral steroids and a trend toward higher medical costs. We did not use the newer HEDIS definition for high-risk asthma, based on 24 months of utilization data because we were seeking to develop a tool that could be used to identify candidates for preventive interventions. Managed care organizations seeking to allocate limited resources may find the revised definition more useful given its ability to identify a smaller more high-risk population.

A limitation of this analysis is that the data was collected from one large health maintenance organization in one geographic region of the United States. Our proposed high-risk definition should to be tested in other clinical settings and populations. One strength of this study is the inclusion of structured youth and parent interviews, including measures of asthma symptoms and asthma-related functioning, as well as automated data on physician diagnosis and asthma-related treatment in a large sample of youth with asthma. Another strength is the depth of data regarding costs and utilization. The analysis of the 2006 HEDIS and revised definitions in this study did not include tests of sensitivity and specificity, because of the lack of a gold-standard, however the administrative and survey data available to this analysis provided a unique opportunity to link the high- and low-risk groups with reports of functional status and health services costs.

### Conclusion

The revised definition for high-risk asthma proposed here is an easily applied tool for health plans wanting to identify a subset of youth with asthma who are likely to benefit from care management based on their risk of poor medical and cost outcomes.

## REFERENCES

1. Akinbami L. The state of childhood asthma, United States, 1980−2005. Adv Data Dec 12;2006 (381): 1–24. [PubMed: 17180851]

2. Lin S, Kielb C, Chen Z, Hwang SA. Childhood asthma hospitalization rates, childhood asthma prevalence, and their relationships in Erie County, New York. J Asthma Oct;2005 42(8):653–658. [PubMed: 16266956]

3. Lozano P, Sullivan SD, Smith DH, Weiss KB. The economic burden of asthma in US children: estimates from the National Medical Expenditure Survey. J Allergy Clin Immunol Nov;1999 104(5): 957–963. [PubMed: 10550739]

4. Perrin JM, Bloom SR, Gortmaker SL. The increase of childhood chronic conditions in the United States. Jama Jun 27;2007 297(24):2755–2759. [PubMed: 17595277]

5. Greineder DK, Loane KC, Parks P. Reduction in resource utilization by an asthma outreach program. Arch Pediatr Adolesc Med Apr;1995 149(4):415–420. [PubMed: 7704170]

6. Karnick P, Margellos-Anast H, Seals G, Whitman S, Aljadeff G, Johnson D. The pediatric asthma intervention: a comprehensive cost-effective approach to asthma management in a disadvantaged inner-city community. J Asthma Jan-Feb;2007 44(1):39–44. [PubMed: 17365203]

7. Kelly CS, Morrow AL, Shults J, Nakas N, Strope GL, Adelman RD. Outcomes evaluation of a comprehensive intervention program for asthmatic children enrolled in medicaid. Pediatrics May;2000 105(5):1029–1035. [PubMed: 10790458]

8. Lozano P, Finkelstein JA, Carey VJ, et al. A multisite randomized trial of the effects of physician education and organizational change in chronic-asthma care: health outcomes of the Pediatric Asthma Care Patient Outcomes Research Team II Study. Arch Pediatr Adolesc Med Sep;2004 158(9):875–883. [PubMed: 15351753]

9. Leone FT, Grana JR, McDermott P, MacPherson S, Hanchak NA, Fish JE. Pharmaceutically-based severity stratification of an asthmatic population. Respir Med Nov;1999 93(11):788–793. [PubMed: 10603627]

10. Schatz M, Nakahiro R, Jones CH, Roth RM, Joshua A, Petitti D. Asthma population management: development and validation of a practical 3-level risk stratification scheme. Am J Manag Care Jan; 2004 10(1):25–32. [PubMed: 14738184]

11. Cabana MD, Slish KK, Nan B, Clark NM. Limits of the HEDIS criteria in determining asthma severity for children. Pediatrics Oct;2004 114(4):1049–1055. [PubMed: 15466104]

12. Richardson LP, Lozano P, Russo J, McCauley E, Bush T, Katon W. Asthma symptom burden: relationship to asthma severity and anxiety and depression symptoms. Pediatrics Sep;2006 118(3): 1042–1051. [PubMed: 16950996]

13. Katon W, Lozano P, Russo J, McCauley E, Richardson L, Bush T. The prevalence of DSM-IV anxiety and depressive disorders in youth with asthma compared with controls. J Adolescent Health Nov; 2007 41(5):455–463.

14. Mitchell H, Senturia Y, Gergen P, et al. Design and methods of the National Cooperative Inner-City Asthma Study. Pediatr Pulmonol Oct;1997 24(4):237–252. [PubMed: 9368258]

15. National Asthma Education and Prevention Program. Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma. National Institutes of Health; Bethesda, MD: 2007.

16. Asmussen L, Olson LM, Grant EN, Fagan J, Weiss KB. Reliability and validity of the Children's Health Survey for Asthma. Pediatrics Dec;1999 104(6):e71. [PubMed: 10586005]

17. Fishman P, Shay D. Development and estimation of a pediatric chronic disease score using automated pharmacy data. Med Care 1999;37(9):874–883. [PubMed: 10493466]

18. StataCorp. Stata Statistical Software: Release 8. StataCorp LP; College Station, TX: 2003.

19. Katon WJ, Richardson L, Russo J, Lozano P, McCauley E. Quality of mental health care for youth with asthma and comorbid anxiety and depression. Med Care Dec;2006 44(12):1064–1072. [PubMed: 17122709]

| 2006 HEDIS Definition | Revised Definition |
|---|---|
| ≥1 emergency room visits for asthma | ≥1 emergency room visits for asthma |
| or ≥1 hospitalizations for asthma | or ≥1 hospitalizations for asthma |
| or ≥4 prescriptions for asthma | or ≥ 1 oral steroid prescriptions for asthma |
| or ≥4 ambulatory visits for asthma and ≥ 2 prescriptions for asthma | |

Each definition is based on utilization in a 12-month period.

**Figure 1.**
2006 HEDIS and Revised Definitions of High-risk Asthma

**Table 1**

Patient characteristics and asthma related function of total sample and risk groups

| | Total | 2006 HEDIS Definition | | Revised Definition | | Comparison of High-risk groups (p-value) |
|---|---|---|---|---|---|---|
| | | High-risk 518 (67%) | Low-risk 251 (33%) | High-risk 223 (29%) | Low-risk 546 (71%) | |
| N | 769 | 518 | 251 | 223 | 546 | |
| Age | 14.05 | 13.98 | 14.17 | * 14.25 | 13.96 | < 0.05 |
| Female % | 47% | 46% | 48% | 50% | 46% | NS |
| Parental education: ≥ some college % | 84% | 84% | 85% | * 80% | 86% | NS |
| *Parent report of child's race:* | | | | | | NS |
| White % | 79% | 79% | 79% | 78% | 79% | |
| Black % | 6% | 6% | 7% | 8% | 5% | |
| Asian, Hawaiian and PI % | 3% | 4% | 2% | 4% | 3% | |
| Native American % | 7% | 7% | 6% | 6% | 7% | |
| Other % | 3% | 3% | 4% | 4% | 3% | |
| Ethnicity — Hispanic % | 5% | 4% | 6% | 6% | 4% | NS |
| Basic Health Plan Enrollee % | 5% | 5% | 5% | 4% | 6% | NS |
| Medicaid enrollee % | 15% | 17% | 13% | 16% | 15% | NS |
| Median income of census tract (mean) | $50,303 | $49,721 * | $51,527 | $48,817 *** | $50,929 | NS |
| Pediatric Chronic Disease Score | 648 | 694 *** | 552 | 830 *** | 573 | NS |
| Years since diagnosis with asthma | 7.21 | 7.57 *** | 6.45 | 7.82 * | 6.95 | NS |
| Asthma symptoms days in prior 2 weeks | 3.88 | 4.12 ** | 3.40 | 4.42 * | 3.65 | NS |
| Intermittent asthma (0–4 days out of 14) | 68% | 66% | 71% | 65% | 68% | NS |
| CHS-A — Physical Health | 73.40 | 73.17 | 73.87 | 70.34 ** | 74.64 | < 0.05 |
| CHS-A — Activity Limitations | 83.45 | 83.09 | 84.20 | 82.07 | 84.02 | NS |
| CHS-A — Emotional Health | 83.70 | 82.84 ** | 85.47 | 82.15 * | 84.32 | NS |

Asterisks denote the statistical significance of the comparison between high- and low-risk groups for each by Chi Square or T-test:

In the comparison of high-risk groups from each definition, p-values are shown or NS denotes the difference is not significant at the level of $p < 0.05$.

CHS-A = Child Health Survey — Asthma.

***
p < 0.001

**
p < 0.01

*
p < 0.05.

**Table 2**

Number of youth captured by high-risk definition criteria (N=769)

| **HEDIS definition criteria:** | | **Number (%) of youth meeting individual criterion:** | |
|---|---|---|---|
| Inpatient | ≥1 inpatient hospitalizations | 9 | (1.2%) |
| ED | ≥1 emergency department visits | 60 | (7.8%) |
| Rx | ≥4 prescriptions for asthma medication | 496 | (64.5%) |
| Visits + Rx | ≥4 ambulatory visits and ≥2 prescriptions for asthma medication | 44 | (5.7%) |
| **New criterion in revised definition:** | | | |
| OS | ≥1 prescriptions for oral steroids | 195 | (25.4%) |
| **Criteria added successively to form HEDIS definition:** | | **Cumulative number of youth meeting criteria:** | |
| Inpatient | | 9 | (1.2%) |
| Inpatient or ED | | 65 | (8.5%) |
| Inpatient or ED or RX | | 514 | (66.8%) |
| Inpatient or ED or RX or Visits + RX | | 518 | (67.4%) |
| **Criteria added successively to form revised definition:** | | **Cumulative number of youth meeting criteria:** | |
| Inpatient | | 9 | (1.2%) |
| Inpatient or ED | | 65 | (8.5%) |
| Inpatient or ED or OS | | 223 | (29.0%) |

ED: ≥1 emergency department visits for asthma

Inpatient: ≥1 inpatient hospitalizations for asthma

OS: ≥1 oral steroid prescriptions for asthma

Rx: ≥4 prescriptions for asthma medication

Visits + Rx: ≥4 ambulatory visits for asthma and ≥2 prescriptions for asthma medication

**Table 3**

Health care cost and utilization for total sample and risk groups

| | Total | 2006 HEDIS Definition | | Revised Definition | | Comparison of High-risk groups (p-value) |
|---|---|---|---|---|---|---|
| | | High-risk | Low-risk | High-risk | Low-risk | |
| N | 769 | 518 (67%) | 251 (33%) | 223 (29%) | 546 (71%) | |
| **Year 1 — Identification of risk** | | | | | | |
| *Mean cost and utilization per patient:* | | | | | | |
| Total health services cost | $2,759 | $2,985 | $2,294 | ***$4,536 | $2,034 | < 0.05 |
| Emergency dept. visits for asthma | 0.09 | *** 0.14 | 0 | *** 0.31 | 0 | < 0.001 |
| Inpatient hospitalizations for asthma | 0.03 | ** 0.05 | 0 | ** 0.11 | 0 | NS |
| Outpatient visits for asthma | 1.12 | *** 1.21 | 0.94 | *** 1.72 | 0.87 | < 0.001 |
| Prescriptions for asthma medication | 6.46 | *** 8.61 | 2.02 | *** 9.11 | 5.38 | NS |
| Prescriptions for oral steroids | 0.41 | *** 0.54 | 0.14 | *** 1.42 | 0 | < 0.001 |
| *Asthma medication profile:* | | | | | | |
| No medications % | 4% | *** 1% | 8% | *** 0% | 3% | < 0.05 |
| Reliever only % | 25% | *** 15% | 45% | *** 4% | 33% | < 0.001 |
| Controller without oral steroid % | 46% | *** 53% | 32% | *** 8% | 62% | < 0.001 |
| Any oral steroid use % | 25% | *** 31% | 13% | *** 87% | 0% | < 0.001 |
| **Year 2 — Follow Up** | | | | | | |
| *Mean cost and utilization per patient:* | | | | | | |
| Total health services cost | $2,503 | *** $2,883 | $1,717 | * $3,499 | $2,095 | NS |
| Emergency dept. visits for asthma | 0.07 | *** 0.09 | 0.02 | *** 0.16 | 0.03 | < 0.05 |
| Inpatient hospitalizations for asthma | 0.02 | ** 0.03 | 0 | 0.04 | 0.01 | NS |
| Outpatient visits for asthma | 0.78 | *** 0.90 | 0.51 | *** 1.04 | 0.69 | NS |
| Prescriptions for asthma medication | 4.65 | *** 5.98 | 1.91 | *** 6.17 | 4.03 | NS |
| Prescriptions for oral steroids | 0.24 | *** 0.30 | 0.10 | *** 0.49 | 0.13 | < 0.01 |
| *Asthma medication profile:* | | | | | | |
| No medications % | 21% | *** 14% | 35% | 18% | 21% | NS |
| Reliever only % | 26% | ** 24% | 32% | *** 18% | 30% | < 0.05 |
| Controller without oral steroid % | 46% | *** 42% | 22% | 33% | 37% | < 0.05 |
| Any oral steroid use % | 16% | *** 20% | 9% | *** 30% | 11% | < 0.01 |

Asterisks denote the statistical significance of the comparison between high- and low-risk groups within each definition by T-test:

In the comparison of high-risk groups from each definition, p-values are shown or NS denotes the difference is not significant at the level of p<0.05

\*\*\*
 p < 0.001

\*\*
 p < 0.01

\*
 p < 0.05