

Asthma-specific Quality of Life and Subsequent Asthma Emergency Hospital Care

Michael Schatz, MD; Robert S. Zeiger, MD, PhD; David Mosen, PhD;
and William M. Vollmer, PhD

Objective: To identify an optimal cut-point score on the Mini-Asthma Quality of Life Questionnaire (mini-AQLQ) to predict subsequent asthma exacerbations, and to determine the additional risk conferred by a prior history of acute episodes.

Study Design: Cross-sectional survey linked to administrative records.

Methods: A total of 1006 HMO patients with active asthma completed surveys that included the mini-AQLQ and prior-year history of acute episodes. Surveys were linked to administrative data that captured asthma emergency department and hospital care (emergency hospital care) for the year after the survey. Optimal mini-AQLQ cut-point scores were determined by stepwise logistic regression analyses using subsequent-year asthma emergency hospital care as the outcome and various mini-AQLQ cut-points as the predictors. Predictive properties of the 2 risk factors (mini-AQLQ cut-points and prior acute episodes) were determined.

Results: A mini-AQLQ cut-point of 4.7 was most significantly associated with subsequent exacerbations in patients without a history of prior acute episodes. The presence of either a mini-AQLQ score <4.7 or a history of prior acute episodes provided high sensitivity (90.4%) and identified a group nearly 6 times more likely to require emergency hospital care than patients with neither risk factor. The presence of both risk factors provided high specificity (79.2%) and resulted in a risk ratio of 9.5 compared with the absence of both risk factors.

Conclusion: Asthma-specific quality of life and a history of acute episodes can be used together to identify patients with clinically meaningful higher and lower risks of subsequent acute exacerbations.

(Am J Manag Care. 2008;14(4):206-211)

For author information and disclosures, see end of text.

Asthma is a common medical problem that causes substantial morbidity, including hospitalizations and unscheduled physician and emergency department visits.^{1,2} Moreover, chronic asthma is associated with very large direct and indirect costs, with a large portion of the direct costs attributable to emergency hospital care.³

Several studies have shown that asthma-specific quality of life is associated with the subsequent risk of emergency hospital care.^{4,7} For this information to be clinically useful, though, a cut-point score on the quality-of-life measure needs to be defined, so that patients can be classified meaningfully according to higher and lower risk for subsequent exacerbations. None of the prior studies have attempted to establish the optimal quality-of-life cut-point score that maximizes both sensitivity and specificity in predicting subsequent emergency hospital care.

In addition, to use quality of life clinically to predict subsequent emergency hospital care, its relationship to other clinically defined risk factors should be clarified. Prior acute episodes have been shown to be the strongest predictor of subsequent acute episodes.⁸⁻¹¹ Three studies have shown that asthma quality of life is independent of prior acute episodes in predicting subsequent emergency hospital care,^{4,6,7} but these studies have not provided a clinically applicable algorithm that incorporates both prior utilization and asthma-specific quality of life. Moreover, 2 of the prior studies defined prior utilization based on computerized data, which may not be available in all clinical settings.^{4,7}

The purpose of this study was to use quality-of-life survey data as well as other information obtained from the patient to develop a practical algorithm for identifying patients at increased risk of subsequent emergency hospital care. This involved identifying a quality-of-life cut-point score that optimally predicts subsequent emergency hospital care in patients with and without a history of unscheduled asthma visits in the past year and determining the additional risk conferred by a prior history of acute episodes.

METHODS

Patients

Patients in this study have been previously described.⁷ Surveys were sent by the Kaiser Permanente Care Man-

In this issue
Take-away Points / p210
www.ajmc.com
Full text and PDF

Asthma Quality of Life and Emergency Care

agement Institute in August 2000 to a random sample of Kaiser Permanente Medical Care Program adult members aged 18-56 years from the Northern California (n = 3072) and Northwest (n = 543) regions who were diagnosed as having persistent asthma in 1999 based on Healthcare Effectiveness Data and Information Set (HEDIS) criteria.¹² The HEDIS criteria comprise 1 or more of the following administrative database observations in a 12-month period: (1) 4 or more asthma medication dispensings, (2) 1 or more emergency department visits or hospitalizations with a primary diagnosis of asthma, or (3) 4 or more asthma outpatient visits with 2 or more asthma medications dispensings.

Completed surveys were returned from 2219 members (61%), of whom 1998 (90%) confirmed a diagnosis of physician-diagnosed asthma. The current study was restricted to the 1100 respondents who met the HEDIS criteria for persistent asthma in 2000 (as well as 1999) and thus had electronic utilization information for 2001 available. Of these patients, 1006 subjects had complete quality-of-life data (see Survey Information section) and are the subjects of this report. The study was approved by the Northern California Region and the Northwest Region Kaiser Permanente Institutional Review Boards.

Survey Information

The survey included information regarding age, sex, race or ethnicity, educational attainment, household income, and smoking history. The survey also included the mini-Asthma Quality of Life Questionnaire (mini-AQLQ),¹³ which includes 15 questions in 4 domains (symptoms, activity, emotions, and environment). Scores range from 1-7, with higher scores indicating better quality of life.

Prior utilization was assessed by the following questions:

1. "In the past 12 months, how many times did you get treatment for an acute asthma attack at a doctor's office, urgent care facility or emergency department (ED)?" Responses range from "None" to "7 or more."
2. "When was your most recent overnight hospitalization for asthma?" Responses included "I have never been hospitalized overnight for asthma," "Within the last week," "Within the last month," "Within the last 6 months," "Within the past year," and "More than one year ago."

Prior acute episodes were defined as an answer of one or more on question 1 above, an overnight hospitalization in the past year on question 2, or both.

Utilization Information

Survey records were matched to year 2001 administrative data by using a unique record number. These electronic data

included asthma hospitalizations and ED visits. For the purpose of these analyses, the outcomes of hospitalizations and ED visits were combined into a single variable to increase power—presence of 1 or more asthma hospitalizations or ED visits (emergency hospital care) versus nonutilization.

Data Analyses

Demographic and utilization characteristics of the population were evaluated by means of descriptive analyses. The optimal cut-point of the mini-AQLQ for predicting year 2001 emergency hospital care was determined by means of stepwise logistic regression analyses with emergency hospital care as the outcome and various mini-AQLQ cut-point levels as the predictors. Mini-AQLQ cut-points between 3.0 and 6.0 at 0.1 increments were offered as potential predictors. The analyses were done separately in patients with and without a history of acute episodes in the prior year.

Hypothesis testing for univariate analyses was by means of Wilcoxon (continuous variables) or chi-square (categorical variables) tests. Multivariable analyses were performed using logistic regression methodology in which the outcome was year 2001 emergency hospital care and the predictors were (1) mini-AQLQ score (optimal cut-point) and (2) prior acute episodes (as defined above, in the Survey Information section). To determine the clinical significance of the findings, predictive properties were evaluated. *Sensitivity* was defined as the proportion of subjects with subsequent utilization who were in the high-risk group. *Specificity* was defined as the proportion of participants without subsequent utilization who were not in the high-risk group. *Positive predictive value* was defined as the proportion of patients in the high-risk group with subsequent utilization. *Negative predictive value* was defined as the proportion of participants not in the high-risk group who did not experience subsequent utilization. Finally, a risk ratio was calculated as the risk of the outcome in patients with the risk factor or factors divided by the risk in patients without the risk factor or factors.

Nominal 2-tailed statistical significance for all analyses was set at $P < .05$. All analyses were performed using SAS statistical software (SAS version 8.2 for Windows, SAS Institute Inc, Cary, North Carolina).

RESULTS

The majority of the patients were white, female, well educated (at least some college), not poor (annual income $> \$35,000$), and nonsmokers.⁷ In 2001, 82.2% of patients received inhaled corticosteroids, and 11.3% of the study patients had emergency hospital care for asthma.

■ METHODS ■

■ **Table 1.** Univariate Relationships of Predictors to Emergency Hospital Care in the Follow-up Year

Predictor	Probability of Subsequent Emergency Hospital Care, %		Odds Ratio (95% CI)	P
	Patients With Predictor	Patients Without Predictor		
Total cohort (n = 1006)*				
mini-AQLQ \leq 4.7	19.4 (86/444)	5.0 (28/562)	4.6 (2.9, 7.2)	<.0001
mini-AQLQ \leq 4.3	21.9 (74/338)	6.0 (40/668)	4.4 (2.9, 6.6)	<.0001
Acute episodes in prior year	20.0 (87/435)	4.7 (27/571)	5.0 (3.2, 7.9)	<.0001
Acute episodes in prior year (n = 435)				
mini-AQLQ \leq 4.7	27.3 (70/256)	9.5 (17/179)	3.6 (2.0, 6.3)	<.0001
mini-AQLQ \leq 4.3	30.0 (63/210)	10.7 (24/225)	3.6 (2.1, 6.0)	<.0001
No acute episodes in prior year (n = 571)				
mini-AQLQ \leq 4.7	8.5 (16/188)	2.9 (11/383)	3.1 (1.4, 6.9)	.003
mini-AQLQ \leq 4.3	8.6 (11/128)	3.6 (16/443)	2.5 (1.1, 5.6)	.019

*Patients whose utilization and mini-AQLQ data were complete.
Mini-AQLQ indicates Mini-Asthma Quality of Life Questionnaire; CI, confidence interval.

Relationships of Risk Factors to Subsequent Emergency Hospital Care

A mini-AQLQ cut-point score of 4.7 was chosen in the stepwise logistic regression model for patients without prior acute episodes (odds ratio [OR] = 3.1; 95% confidence interval [CI] = 1.4, 6.9). An mini-AQLQ cut-point score of 4.3 was chosen in the stepwise logistic regression model for patients with prior acute episodes (OR = 3.5; 95% CI = 2.1, 5.9). In the total cohort, a low mini-AQLQ score (either cut-point) or a history of acute episodes in the prior year was associated with an approximate 20% risk of subsequent emergency hospital care compared with a 5% to 6% risk in patients without the predictor (Table 1).

Although a cut-point of 4.3 was more significantly related to subsequent exacerbations in the logistic regression model than a cut-point of 4.7 in patients with prior episodes, the difference would appear to be clinically unimportant because the 2 cut-points produced equal ORs for subsequent exacerbations in these patients (Table 1). Because a cut-point of 4.7 was associated with higher ORs in the total cohort and in patients without prior acute episodes, this mini-AQLQ cut-point was chosen to define higher risk in subsequent analyses.

Prior acute episodes (OR = 3.8; 95% CI = 2.4, 6.1) and a mini-AQLQ score \leq 4.7 (OR = 3.4; 95% CI = 2.1, 5.4) were independently related to emergency hospital care the following year in the multivariable logistic regression analysis. The C statistic for the area under the receiver operating characteristic curve was 0.69 for prior acute episodes alone, 0.68 for a

mini-AQLQ score \leq 4.7 alone, and 0.75 when both were included in the model.

Predictive Properties of Risk Factors

Because prior acute episodes and low mini-AQLQ score appeared to be independent predictors of subsequent emergency hospital utilization, the predictive properties of the presence of either or both of these risk factors were evaluated (Table 2). The presence of either risk factor provided high sensitivity (90.4%) and identified a group nearly 6 times more likely to require emergency hospital care than patients with neither of these risk factors. The presence of both risk factors provided high specificity (79.2%), and patients with both risk factors had a risk ratio of 9.5 compared with patients who had neither risk factor (Table 2).

DISCUSSION

Emergency hospital care exacts substantial human and economic costs. Identification of patients at increased risk of requiring such care could facilitate targeted intervention to prevent such occurrences. The current study shows that information easily obtainable from the patient (asthma-specific quality of life and a history of episodes requiring unscheduled visits in the past year) can be used to identify patients at clinically meaningful increased risk of future acute episodes. Low quality of life (based on data-derived optimal cut-point scores)

and prior acute episodes each independently increase the risk of requiring such care approximately 4-fold. Ninety percent of patients who subsequently required emergency hospital care had 1 of these risk factors. More than 25% of patients with both risk factors required subsequent asthma hospitalizations or ED visits, a nearly 10-fold increased risk compared with that of patients who had neither of these high-risk markers.

Prior studies identified low quality of life as a risk factor for subsequent asthma ED visits and hospitalizations,^{4,7} even after adjusting for prior emergency hospital utilization.^{4,6,7} However, no prior studies attempted to determine the quality-of-life cut-point score that provides the best predictive information regarding subsequent utilization. In our prior study with the mini-AQLQ,⁷ we used a cut-point of 3.9, based on the cut-point for the lower quartile of patient scores. Tierney and colleagues,⁶ who administered the 32-item version of the AQLQ, used <4, 4-5, and >5 as their cut-points, but no rationale for those cut-points was provided. Although the relationship between asthma-specific quality of life and subsequent emergency hospital care is almost certainly linear, optimal cut-points are necessary for clinical purposes.

The current study has shown that the optimal cut-point score for predicting subsequent exacerbations varies depending on whether or not the patient has a history of recent exacerbations. The optimal cut-point score in patients with a history of prior exacerbations (4.3) was lower than the optimal cut-point score in patients without acute episodes requiring unscheduled care in the prior year (4.7). This makes sense because patients with prior exacerbations could be expected to have lower baseline quality-of-life scores than patients without such episodes. However, the current study also suggests that either cut-point defined the same degree of relative risk in patients with prior episodes and that a cut-point of 4.7 defined a somewhat higher degree of relative risk in patients without prior acute episodes (Table 1). Thus, because it would be more clinically useful to define 1 cut-point score, a cut-point of 4.7 was chosen to use for both groups.

The information in this study could be used practically in both population and individual patient management. For population management, information about quality of life and

■ **Table 2.** Predictive Properties of Prior Acute Episodes, Low Mini-AQLQ Score, or Both for Subsequent Emergency Hospital Care (n = 1006)

Parameter	Percentage			
	Mini-AQLQ Score <4.7	Prior Acute Episodes	Either*	Both†
Prevalence of the predictor	44.1	43.2	61.9	25.5
Sensitivity	75.4	76.3	90.4	61.4
Specificity	59.9	61.0	41.7	79.2
PPV	19.4	20.0	16.5	27.3
NPV	95.0	95.3	97.1	94.1
Risk ratio‡	3.9	4.2	5.8	9.5
			(vs neither)	(vs neither)

*Mini-AQLQ score <4.7 or prior acute episodes.
 †Mini-AQLQ score <4.7 and prior acute episodes.
 ‡The risk of the outcome in patients with the risk factor or factors divided by the risk in patients without the risk factor or factors.
 Mini-AQLQ indicates Mini-Asthma Quality of Life Questionnaire; PPV, positive predictive value; NPV, negative predictive value.

prior acute episodes could be obtained by mailed survey or electronically. Use of both high-risk markers compared with only 1 marker increases potential sensitivity by 18% (from 76%-90%) and potential specificity by 30% (from 61%-79%) (Table 2). Depending on the goals and interventions involved in a specific population management initiative, a high-sensitivity approach (either high-risk marker) or a high-specificity approach (both high-risk markers) could be utilized. For individual patients, the survey could be completed before seeing the clinician. Patients with either high-risk marker have a substantial (20%) risk of subsequent acute episodes and thus would be candidates for aggressive management of triggers and comorbidities, consideration of a step-up in long-term control therapy, and provision of an explicit action plan for increased symptoms.¹⁴ Such an intervention would be even more important in patients with both high-risk markers, who have a 27% risk of subsequent acute episodes during the next year based on the current data (Table 2).

The information in this study also could potentially be used in clinical trials that test the effects of interventions on asthma exacerbations. There is recent interest in risk-adjusted efficacy in clinical trials—the assessment of efficacy outcomes in groups stratified by baseline risks.¹⁵ Prior acute episodes and low baseline mini-AQLQ scores defined by the cut-point in this study could be used to stratify baseline risk for risk-adjusted efficacy assessments of the effect of an intervention on subsequent asthma exacerbations.

An important issue is the generalizability of the current findings. It seems likely that the independent associations

Take-away Points

Asthma-specific quality of life and prior history of exacerbations can be used to define future risks of asthma exacerbation.

- Either a score of <4.7 on the Mini-Asthma Quality of Life Questionnaire or a history of prior acute episodes provided high sensitivity (90.4%) and identified a group nearly 6 times more likely to require emergency hospital care than patients with neither risk factor.
- The presence of both risk factors provided high specificity (79.2%) and resulted in a risk ratio of 9.5 compared with the absence of both risk factors.
- Such information could be useful for determining baseline risks in clinical trials as well as for individual and population asthma management.

between quality of life and prior acute episodes in predicting subsequent exacerbations and the lower optimal quality-of-life cut-point score in patients with prior exacerbations would persist in other populations and with other asthma-specific quality-of-life tools. However, the quantitative relationships found in this study could be affected by characteristics of the healthcare system (an HMO with good access to chronic and acute care), the patients (nonpoor and white), and their therapy (a high proportion received inhaled corticosteroids), although it is not certain whether variations in these characteristics would strengthen or weaken the observed relationships. A particular issue regarding generalizability is the high educational status of the current sample. Because the mini-AQLQ depends on literacy, the current results may not apply to populations with lower literacy levels. It also is not clear whether the specific optimal cut-points defined in this study would be duplicated in other populations using the mini-AQLQ. Pending additional data, we recommend a high-risk mini-AQLQ cut-point score of 4.7.

This study does have some potential limitations. Not all patients completed questionnaires, although a 61% response rate is reasonable for this type of mail-in questionnaire study. The 2001 outcomes for the patients in this study compared with the general population who had persistent asthma in the 2 regions (G. Tom, unpublished data, 2003) for dispensing of >14 β -agonist canisters (15% vs 13%) and for emergency hospital care (11% vs 9%) suggest that the responders had somewhat more severe or uncontrolled asthma than the nonresponders. Further selection bias could have been introduced by the unavailability of utilization data for all subjects who completed the survey. Because patients without utilization data would not have been considered to have persistent asthma in 2000, that also biases the study sample in favor of those with more severe asthma.

Another potential limitation of this study is that it did not include pulmonary function data. This means that the diagnosis of asthma was not necessarily confirmed by pulmonary

function tests, although the current study definition of asthma (physician diagnosis) has been found to be valid for use in epidemiologic studies.¹⁶ Lower pulmonary function, especially forced expiratory volume in 1 second (FEV₁), has been shown to predict subsequent exacerbations.^{8,17-19} It would be of interest to know whether FEV₁ and the mini-AQLQ score would function independently as risk factors for subsequent exacerbations, but no study in which both have been measured has been published to our knowledge. One study found that a peak flow less than 50% of predicted values was a significant univariate predictor of exacerbations within 12 months, but peak flow was no longer a significant predictor when controlling for AQLQ scores.⁶

Other questionnaires, such as the Asthma Therapy Assessment Questionnaire^{20,21} and the Asthma Control Test,²² also have been shown to predict subsequent emergency hospital care. In one study, patients with Asthma Therapy Assessment Questionnaire scores of 3 or 4 (poorest control) were 2.5 times more likely to experience subsequent acute exacerbations than patients with Asthma Therapy Assessment Questionnaire scores of 0 (no control problems).²¹ In another study, patients with poorly controlled asthma based on Asthma Control Test scores ≤ 15 were 2.4 times more likely to require emergency hospital care in the following year than patients with controlled asthma based on an Asthma Control Test score ≥ 20 .²² It would be of interest to compare the accuracy and ease of use of these questionnaires with the accuracy and ease of use of the mini-AQLQ in predicting subsequent exacerbations. However, such a study would require concurrent use of all of these tools and assessment of ease of use, which were not parts of the current study.

In summary, this study has shown that asthma-specific quality of life and a history of recent acute episodes can be used together to identify patients with substantially higher and lower risks of subsequent acute exacerbations. Optimal cut-points in additional populations and the relationship of these risk factors to lower FEV₁ in predicting subsequent exacerbations require further study, as does comparison of the mini-AQLQ with other questionnaires for this purpose. In addition, it is hoped that future studies could demonstrate improved outcomes after targeted interventions in patients with these risk factors.

Author Affiliations: From the Department of Allergy, Kaiser-Permanente Medical Center, San Diego, CA (MS, RSZ) and the Center for Health Research, Kaiser-Permanente Medical Care Program, Portland, OR (DM, WMV).

Author Disclosure: The authors (RSZ, DM, WMV) report no relationship or financial interest with any entity that would pose a conflict of inter-

est with the subject matter of this article. Dr. Schatz is a consultant for GlaxoSmithKline, has a grant pending from Schering Plough, has received grants from GlaxoSmithKline, Sanofi-Aventis, and Merck, and has received lecture fees from GlaxoSmithKline and Genetech.

Funding Source: This study was supported by the Kaiser-Permanente Care Management Institute, Oakland, CA.

Authorship Information: Concept and design (MS, RSZ, DM); acquisition of data (WMV); analysis and interpretation of data (MS, DM, WMV); drafting of the manuscript (MS, RSZ, DM); critical revision of the manuscript for important intellectual content (MS, RSZ, DM, WMV); statistical analysis (MS); obtaining funding (WMV); and administrative, technical, or logistic support (RSZ).

Address correspondence to: Michael Schatz, MD, Department of Allergy, Kaiser-Permanente Medical Center, 7060 Clairemont Mesa Blvd, San Diego, CA 92111. E-mail: michael.x.schatz@kp.org.

REFERENCES

1. Mannino DM, Homa DM, Akinbami LJ, Moorman JE, Gwynn C, Redd SC. Surveillance for asthma—United States, 1980-1999. *MMWR Surveill Summ.* 2002;51(1):1-13.
2. Centers for Disease Control and Prevention (CDC). Asthma prevalence and control characteristics by race/ethnicity—United States, 2002. *MMWR Morb Mortal Wkly Rep.* 2004;53(7):145-148.
3. Smith DH, Malone DC, Lawson KA, et al. A national estimate of the economic costs of asthma. *Am J Respir Crit Care Med.* 1997;156(3 Pt 1):787-793.
4. Eisner MD, Ackerson LM, Chi F, et al. Health-related quality of life and future health care utilization for asthma. *Ann Allergy Asthma Immunol.* 2002;89(1):46-55.
5. Magid DJ, Houry D, Lyons E, Rumsfeld JS. Health-related quality of life predicts emergency department utilization for patients with asthma. *Ann Emerg Med.* 2004;43(5):551-557.
6. Tierney WM, Roesner JF, Seshadri R, Lykens MG, Murray MD, Weinberger M. Assessing symptoms and peak expiratory flow rate as predictors of asthma exacerbations. *J Gen Intern Med.* 2004;19(3):237-242.
7. Schatz M, Mosen D, Apter AJ, et al. Relationship of validated psychometric tools to subsequent medical utilization for asthma. *J Allergy Clin Immunol.* 2005;115(3):564-570.
8. Li D, German D, Lulla S, Thomas RG, Wilson SR. Prospective study of hospitalization for asthma: a preliminary risk factor model. *Am J Respir Crit Care Med.* 1995;151(3 Pt 1):647-655.
9. Lieu TA, Quesenberry CP, Sorel ME, Mendoza GR, Leong AB. Computer-based models to identify high-risk children with asthma. *Am J Respir Crit Care Med.* 1998;157(4 Pt 1):1173-1180.
10. Lieu TA, Capra AM, Quesenberry CP, Mendoza GR, Mazar M. Computer-based models to identify high-risk adults with asthma: is the glass half empty or half full? *J Asthma.* 1999;36(4):359-370.
11. Schatz M, Cook EF, Joshua A, Petitti D. Risk factors for asthma hospitalization in a managed care organization: development of a clinical prediction rule. *Am J Manag Care.* 2003;9(8):538-547.
12. National Committee for Quality Assurance. *HEDIS Technical Specifications.* Washington, DC: National Committee for Quality Assurance; 2005.
13. Juniper EF, Guyatt GH, Cox FM, Ferrie DJ, King DR. Development and validation of the Mini Asthma Quality of Life Questionnaire. *Eur Respir J.* 1999;14(1):32-38.
14. National Heart, Lung, and Blood Institute, National Asthma Education and Prevention Program. *Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma.* 2007. <http://www.nhlbi.nih.gov/guidelines/asthma/asthgdln.pdf>. Accessed February 4, 2008.
15. Kent DM, Hayward RA. Limitations of applying summary results of clinical trials to individual patients: the need for risk stratification. *JAMA.* 2007;298(10):1209-1212.
16. Toren K, Brisman J, Jarvholm B. Asthma and asthma-like symptoms in adults assessed by questionnaires: a literature review. *Chest.* 1993;104(2):600-608.
17. Cowie RL, Underwood MF, Revitt SG, Field SK. Predicting emergency department utilization in adults with asthma: a cohort study. *J Asthma.* 2001;38(2):179-184.
18. Rasmussen F, Taylor DR, Flannery EM, et al. Risk factors for hospital admission for asthma from childhood to young adulthood: a longitudinal population study. *J Allergy Clin Immunol.* 2002;110(2):220-227.
19. Osborne ML, Pedula KL, O'Hollaren M, et al. Assessing future need for acute care in adult asthmatics: the Profile of Asthma Risk Study: a prospective health maintenance organization-based study. *Chest.* 2007;132(4):1151-1161.
20. Vollmer WM, Markson LE, O'Connor E, et al. Association of asthma control with health care utilization: a prospective evaluation. *Am J Respir Crit Care Med.* 2002;165(2):195-199.
21. Peters D, Chen C, Markson LE, et al. Using an asthma control questionnaire and administrative data to predict health-care utilization. *Chest.* 2006;129(4):918-924.
22. Schatz M, Zeiger RS, Drane A, et al. Reliability and predictive validity of the Asthma Control Test administered by telephone calls using speech recognition technology. *J Allergy Clin Immunol.* 2007;119(2):336-343. ■