

Change in Asthma Control Over Time: Predictors and Outcomes

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What is already known about this topic? Maintenance of asthma control over time is a clear goal of national asthma guidelines.

What does this article add to our knowledge? The degree of asthma control at one point in time is strongly related to the achievement or maintenance of control and to asthma exacerbations over time. Predictors of maintenance of control can be identified.

How does this study impact current management guidelines? Patients with uncontrolled asthma should receive intensive management and follow-up in an attempt to achieve well-controlled asthma over time.

BACKGROUND: Maintenance of asthma control over time is a clear goal of national asthma guidelines, but few studies have addressed the natural history of asthma control over time.

OBJECTIVE: To assess the impairment domain of asthma control over time in patients with persistent asthma and to determine predictors and consequences of controlled and uncontrolled asthma over time.

METHODS: Patients 18-56 years old with persistent asthma who completed baseline (November 2007) and follow-up asthma surveys (April, July, October 2008) were included in the study. The survey included the Asthma Control Test as well as questions regarding other patient and asthma characteristics.

Health care utilization (pharmacy and exacerbations) for 2008 was obtained from administrative data.

RESULTS: The baseline and first follow-up surveys were completed by 1267 patients, and all 4 surveys were completed by 782 patients. Patients with well-controlled asthma at baseline were significantly more likely ($P < .0001$) to have well-controlled asthma over the following year (76.2%-80.4%) than patients with uncontrolled asthma at baseline (33.5%-36.9%). Patients whose asthma control improved over the first several months of follow-up experienced significantly ($P < .05$) fewer exacerbations over the subsequent year than patients with initially uncontrolled asthma who did not improve.

CONCLUSION: Degree of asthma control at one point in time is strongly related to the achievement or maintenance of control and to asthma exacerbations over time. Patients with uncontrolled asthma, especially very poorly controlled asthma, should receive intensive management and follow-up in an attempt to achieve well-controlled asthma over time. © 2013 American Academy of Allergy, Asthma & Immunology (J Allergy Clin Immunol Pract 2014;2:59-64)

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Achieving asthma control and maintaining it over time are major goals of asthma therapy.¹ Most research on asthma control has focused on achieving control at a point in time and the predictors and consequences of doing so. For example, studies have identified patient and management factors that predict asthma control at a single point in time,² and other studies have identified outcomes based on achieving asthma control at a point in time.³⁻⁵ However, few data exist on factors that affect the maintenance of asthma control over time or that identify the relationship of asthma control over time to asthma outcomes. The purpose of this study was to assess the impairment domain of asthma control over time in a cohort of patients with persistent

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Abbreviations used

ACT- Asthma Control Test

BMI- Body mass index

CI- Confidence interval

ED- Emergency department

SABA- Short-acting β -agonist

asthma and to determine both predictors and consequences of controlled and uncontrolled asthma over time.

METHODS

Patients

This study was approved by the Kaiser Permanente Southern California Institutional Review Board. By using computerized Kaiser Permanente Southern California inpatient, outpatient, pharmacy, and membership records, we identified patients 18-56 years old, with persistent asthma in 2006 (study year 1) based on meeting one or more of the Healthcare Effectiveness Data and Information Set criteria: (1) 4 or more asthma medication dispensings, (2) one or more emergency department (ED) visits or hospitalizations with a principal diagnosis of asthma, or (3) 4 or more asthma outpatient visits, with 2 or more asthma medication dispensings. Only patients with continuous membership in Kaiser Permanente Southern California from 2006 to 2008 were included in the study.

Survey

In November of 2007, 13,933 eligible patients were mailed a survey. The survey included the Asthma Control Test (ACT), a validated tool for assessing the impairment domain of asthma control. Scores range from 5 to 25, with higher scores indicating better control. Scores of >19 , 16-19, and <16 indicate Expert Panel Report 3 defined control categories of well-controlled, not well-controlled, and very poorly controlled asthma, respectively.¹

The survey also included questions regarding (1) race/ethnicity, (2) educational attainment, (3) household income, (4) weight and height (for calculation of body mass index [BMI]), (5) smoking, (6) whether or not a specialist was the patient's "regular source of asthma care," and (7) a history of asthma exacerbations in the prior 12 months, including a hospitalization, unscheduled outpatient or ED visit, or oral corticosteroid course for asthma. The information from the survey was used only for research purposes and was not made available to the clinicians managing the patients.

Patients who completed the baseline surveys from November 2007 were sent follow-up surveys in April (spring), July (summer), and October (fall) of 2008, which also included the ACT. Only survey respondents who reported physician-diagnosed asthma on the baseline survey were included in the study.

Computerized data

The following additional information was captured from the computerized data: (1) sex, (2) age, (3) hospitalization with asthma coded (*International Classification of Diseases, Ninth Revision* 493.xx) as the primary diagnosis or the second diagnosis with another respiratory primary diagnosis, (4) ED visit with asthma coded (*International Classification of Diseases, Ninth Revision* 493.xx) as the primary diagnosis or the second diagnosis with another respiratory primary diagnosis, (5) oral corticosteroid dispensing within 7 days of an encounter coded as an asthma

exacerbation or uncontrolled asthma, (6) short-acting β -agonist (SABA) canisters dispensed, and (7) asthma controller units (inhaled corticosteroid canisters with or without long-acting β -agonist, or a 30-day supply of leukotriene receptor antagonists) dispensed. Medical utilization for asthma (3-7 above) was assessed during 2008.

Data analysis

Baseline demographics, asthma severity, and asthma management as well as comorbidity characteristics were described in the cohort with both baseline and first follow-up surveys completed ($n = 1267$) and the cohort that completed all 4 surveys ($n = 782$). The relationships of baseline control (ACT > 19 vs ACT < 20 and ACT 16-19 vs ACT < 16) to (1) control status at each follow-up survey, and (2) the number of surveys with controlled asthma (ACT > 19) were evaluated by means of χ^2 analysis. Relationships between the change in control status from baseline to the first follow-up surveys and 2008 outcomes (asthma hospitalization or ED visit, oral corticosteroid dispensing linked to an asthma encounter, SABA canisters > 6) were evaluated by univariate logistic regression. Patients with various combinations of well-controlled (ACT > 19), not well-controlled (ACT 16-19), and very poorly controlled (ACT < 16) asthma at baseline and first follow-up surveys were compared with patients with ACT > 19 on both surveys as the reference. Because this involved 8 different comparisons, a Bonferroni correction was applied such that only a P value $< .00625$ was considered significant for this analysis. Finally, the population average effect of each predictor of uncontrolled asthma (ACT ≤ 19) was estimated by multivariate Poisson regression with the generalized estimating equations method to handle the correlated nature of the response variable (4 measures of asthma control per patient). We specified an independent (unstructured) working correlation. Each estimate of a predictor was adjusted for season (time of each survey), patient demographic (age, sex, race/ethnicity, household income, educational level), asthma severity markers (exacerbations in the prior year or 3 months before the survey), management factors (baseline specialist care, controller dispensings), and comorbidities (smoking, BMI). Nominal 2-tailed statistical significance for all analyses except as noted above was set at $P < .05$. All analyses were conducted by using SAS EG version 4.3 (SAS Institute, Cary, NC).

RESULTS

Characteristics of study participants who completed at least the baseline and first follow-up surveys ($n = 1267$) and those who completed all 4 surveys ($n = 782$) are shown in [Table I](#). The 2 cohorts were similar in demographic, socioeconomic, smoking, BMI, and utilization characteristics. The participants were approximately 75% women, 60% white, and 20% Hispanic. More than 80% of participants had more than a high school education, and more than 65% reported a household income higher than \$50,000. A minority of patients (approximately 7%) were smokers, but a substantial proportion ($> 40\%$) were obese ([Table I](#)).

Relationship of baseline control to follow-up control

Patients with controlled asthma at baseline were much more likely to remain controlled over the following year than patients who were uncontrolled at baseline ([Table II](#)). Similarly, patients with not well-controlled asthma (ACT 16-19) at baseline were

TABLE I. Baseline characteristics of study participants who completed both the baseline and first follow-up surveys and those who completed all 4 surveys

Characteristic	Baseline and first follow-up survey (n = 1267)	All 4 surveys (n = 782)
Age (y), mean (SD)	44.9 (10.7)	45.6 (10.3)
Women (%)	74.0	75.3
Race (%)		
White	60.6	62.7
Black	9.7	6.6
Hispanic	20.1	19.6
Other	9.6	10.1
Education > high school (%)	83.4	84.7
Household yearly income > \$50,000 (%)	66.6	68.3
Asthma hospitalization in past year (%)	4.1	3.3
Oral corticosteroid for asthma in past year (%)	38.8	36.2
Regular specialist care (%)	35.8	39.8
Current smoking (%)	7.4	7.0
BMI (%)		
<25 kg/m ²	28.7	31.1
25-29.9 kg/m ²	29.7	27.6
≥30 kg/m ²	41.6	41.3

TABLE II. Relationship of baseline control to subsequent control (based on results on each follow-up survey) in 782 patients with complete ACT data of all 4 surveys

Follow-up survey, 2008	No. (%) patients with ACT > 19 on indicated follow-up survey		P value, χ^2 test
	Baseline ACT > 19 (n = 424)	Baseline ACT ≤ 19 (n = 358)	
April	323 (76.2)	120 (33.5)	<.0001
July	341 (80.4)	132 (36.9)	<.0001
October	327 (77.1)	129 (36.0)	<.0001
	Baseline ACT 16-19 (n = 197)		P value, χ^2 test
	Baseline ACT < 16 (n = 161)		
April	85 (43.2)	35 (21.7)	<.0001
July	89 (45.2)	43 (26.7)	<.0001
October	94 (47.7)	35 (21.7)	<.0001

much more likely to have controlled asthma on any subsequent survey over the following year than patients with very poorly controlled asthma (ACT < 16) (Table II). The majority of patients with controlled asthma at baseline remained controlled on each quarterly survey over the following year (Figure 1). Conversely, the majority of patients with asthma that was very poorly controlled at baseline were not well controlled on any quarterly survey over the following year (Figure 2). Patients with controlled asthmas at baseline remained controlled on more quarterly surveys over the following year than patients with uncontrolled asthma at baseline (Figure 1). Similarly, patients with not well-controlled asthma at baseline had controlled asthma

on more quarterly surveys over the following year than patients with very poorly controlled asthma at baseline (Figure 2).

Relationship of baseline and first follow-up asthma control to asthma outcomes

Asthma outcomes were assessed during 8 months after the first follow-up. The patients with controlled asthma at baseline whose level of control decreased at the first follow-up were not at increased risk of adverse asthma outcomes during the 8 months after the first follow-up compared with patients who had well-controlled asthma at both baseline and first follow-up (Table III).

Patients with not well-controlled asthma at baseline but with controlled asthma at the first follow-up were not at increased risk of adverse asthma outcomes during the 8 months after the first follow-up compared with the patients with well-controlled asthma at both baseline and the first follow-up. In contrast, the patients with not well-controlled asthma at baseline who remained not well controlled at the first follow-up were at increased risk of SABA overuse during the 8 months after the first follow-up (Table III). The patients with not well-controlled asthma at baseline who become very poorly controlled at the first follow-up were at an even greater risk of adverse asthma outcomes (asthma exacerbations and SABA overuse) during the 8 months after the follow-up determination (Table III).

Compared with the patients with well-controlled asthma at both baseline and the first follow-up, the patients with very poorly controlled asthma at baseline who had either not well-controlled or very poorly controlled asthma at the first follow-up were at increased risk of adverse asthma outcomes during the 8 months after the first follow-up, especially if their asthma remained very poorly controlled. In contrast, the patients with very poorly controlled asthma at baseline who had well-controlled asthma 5 months later were not at increased risk of adverse asthma outcomes during the 8 months after the first follow-up (Table III).

Predictors of asthma control over time

Independent risk factors for uncontrolled asthma (ACT ≤ 19) included prior exacerbations, smoking, black race, low income, and increased BMI (Table IV). Asthma was more likely to be well controlled in the summer compared with other time periods (Table IV).

DISCUSSION

Maintenance of asthma control over time is a clear goal of the national asthma guidelines,¹ but few studies have addressed the natural history of asthma control over time. The Epidemiology and Natural History of Asthma: Outcomes and Treatment Regimens study provided longitudinal data regarding asthma control by using a validated tool (the Asthma Therapy Assessment Questionnaire) in a sample of patients with difficult to control asthma.⁶ However, we are not aware of prior studies that assessed the impairment domain of asthma control over time in a general population of patients with asthma in a real-world setting. This novel study has shown that the degree of impairment at a point in time establishes the likelihood of achieving well-controlled asthma over the subsequent year. Patients with well-controlled asthma were much more likely than patients with not well-controlled asthma or patients with very poorly controlled asthma to report well-controlled asthma over time (Table II). Moreover, the current study supports the value of

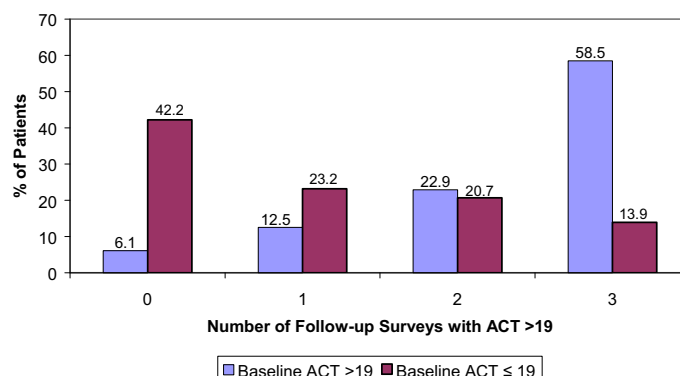


FIGURE 1. The relationship of baseline ACT (>19 vs ≤19) to the number of follow-up surveys (0-3) with ACT > 19 ($P < .0001$).

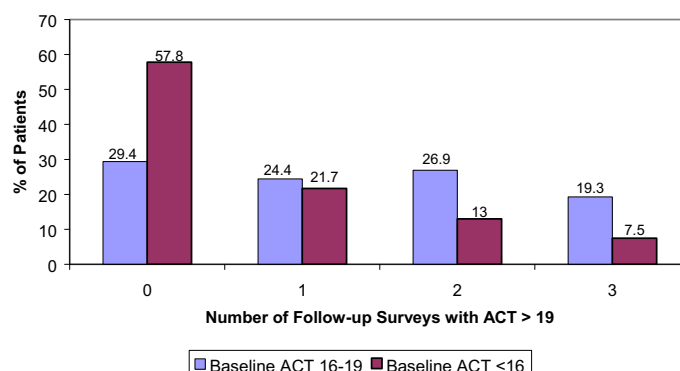


FIGURE 2. The relationship of baseline ACT (16-19 vs <16) to the number of follow-up surveys (0-3) with ACT > 19 ($P < .0001$).

TABLE III. Relationship of baseline and first follow-up asthma control to asthma outcomes during the May 1, 2008, to December 31, 2008, follow-up period (n = 1267)

ACT score			Proportion (%) of patients with outcome		
Baseline (December 2007)	First follow-up (April 2008)	N	Asthma hospitalization/ED visit	Oral corticosteroid dispensing	SABA canisters > 6
>19	>19	494	1.4	9.1	2.6
>19	16-19	105	1.0	13.3	1.0
>19	<16	48	4.2	14.6	2.1
16-19	>19	145	2.1	16.6	4.1
16-19	16-19	119	2.5	16.0	12.6*
16-19	<16	79	10.1*	20.3*	10.1*
<16	>19	51	2.0	13.7	7.8
<16	16-19	82	2.4	19.5*	8.5
<16	<16	144	11.8*	32.6*	17.4*

* $P < .00625$ compared with the reference group (first row patients with ACT > 19 at baseline and at first follow up); because of 8 comparisons, only $P < .00625$ was considered significant (Bonferroni correction).

differentiating not well-controlled asthma from very poorly controlled asthma because patients with very poorly controlled asthma are particularly unlikely to achieve well-controlled asthma over time.

The current study also demonstrated the relationships of changes in asthma control over a 5-month period to subsequent asthma exacerbations and β -agonist overuse. Substantial deterioration in control (well controlled or not well controlled to very poorly controlled) is associated with a significantly increased risk of adverse asthma outcomes. In contrast, improvement in asthma

control over a 5-month period (not well controlled or very poorly controlled to well controlled) is associated with improved outcomes compared with patients who do not achieve well-controlled asthma over this time period.

Prior studies have shown that asthma exacerbations are more likely to occur in the fall and winter,^{7,8} but we are unaware of prior studies that have documented seasonal variation in the impairment domain of asthma control by using a validated tool. The current study clearly showed that asthma was more likely to be well controlled in the summer in a cohort of patients followed

TABLE IV. Independent predictors of uncontrolled asthma (ACT ≤ 19) *

Predictor	Odds ratio (95% CI)
Hospitalization in the past year†	
No	Reference
Yes	2.17 (1.08-4.36)
Oral corticosteroid for asthma in the past year†	
No	Reference
Yes	1.58 (1.25-2.00)
Regular specialist care†	
No	Reference
Yes	0.89 (0.70-1.12)
Current smoker	
No	Reference
Yes	1.96 (1.23-3.14)
Sex†	
Men	Reference
Women	1.16 (0.89-1.51)
Race/ethnicity†	
White	Reference
Black	1.61 (1.0003-2.58)
Hispanic	1.05 (0.78-1.42)
Other	1.08 (0.76-1.53)
Education†	
>High school	Reference
≤High school	1.33 (0.98-1.82)
Household income†	
>\$50,000	Reference
≤\$50,000	1.85 (1.45-2.35)
Age, 10-y increase in age†	0.97 (0.87-1.09)
BMI, 1 unit increase†	1.02 (1.007-1.04)
Oral corticosteroid dispense within 7 d after asthma encounter during 3 mo before the survey	
No	Reference
Yes	1.95 (1.42-2.67)
Total controller units during 3 mo before the survey, 1 unit increase	1.01 (0.98-1.04)
Season	
Fall	Reference
Spring	0.9 (0.83-1.10)
Summer	0.83 (0.72-0.95)

*By multivariate Poisson regression, with the generalized estimating equations method.

†From the baseline survey.

up longitudinally over a 1-year period of time. This observation confirmed the necessity to take season into account when assessing asthma control in epidemiologic studies or clinical trials.

The current study also evaluated risk factors for uncontrolled asthma over time. These results can be compared with studies, which were recently reviewed, that used validated control tools to identify predictors of asthma control at one point in time.² The current study identified the same risk factors for uncontrolled asthma over time as were previously reported for uncontrolled asthma at a single point in time, namely: history of prior exacerbations, black race, lower income, smoking, and increased BMI. Specialist care, which has been associated with better control of asthma impairment at one point in time in prior studies,^{9,10} was not associated with asthma control over time in

the current study. The reasons for this discrepancy are not clear, but the majority of the current cohort observed over time (60%) did not report regular specialist care at the baseline survey.

This study has a number of important clinical implications. The patients with uncontrolled asthma on an encounter (especially if very poorly controlled) have an increased risk of remaining uncontrolled and of incurring subsequent adverse outcomes, including exacerbations. Such patients need a complete management program as recommended by asthma guidelines,¹ which include trigger avoidance, management of comorbidities (including smoking and obesity), optimal step therapy, and attention to inhaler technique and adherence. Patients with uncontrolled asthma should be followed up to be sure that control has improved, which the current study confirmed is associated with an increased likelihood of maintenance of control and a reduced likelihood of exacerbations. The current study also suggested that well-controlled asthma in the summer may not remain well controlled at other times of the year, so follow-up during other seasons for patients seen in the summer with controlled asthma is warranted.

In addition to the real-world setting and general population sample, strengths of the current study include use of the ACT, one of the recommended validated asthma control tools for clinical studies¹¹; longitudinal follow-up of a relatively large cohort of patients over a 1-year period; the ability to assess health care utilization by using objective and robust administrative data; and use of sophisticated time-dependent statistical analyses. However, this study does have some potential limitations. The most important of these is the potential for selection bias in the sample of patients who completed the survey. We showed that, compared with nonresponders, patients who completed the survey in this cohort were more likely to be women, older, in neighborhoods with a higher education and household income, and less likely to be smokers.¹² In addition, respondents experienced fewer exacerbations that required ED visits or oral corticosteroid dispensings and were less likely to receive more than 6 canisters of SABA in the prior year. It is not clear, however, whether or not any of these differences would influence the patterns of asthma control observed over time in the patients who completed the survey. Nonetheless, the potential for selection bias must be considered when interpreting the results of the current study. The characteristics of patients who completed all 4 surveys were generally similar to those of patients who completed the first 2 surveys (Table I).

Another possible limitation of the current study is that it did not specifically include the risk domain of asthma control over time. However, it has been well established that a history of prior asthma exacerbations is the strongest predictor of future exacerbations,² which is the major rationale for the risk domain as defined in current guidelines.¹ Finally, this study did not include pulmonary function in the assessment of asthma control over time. However, it has been shown that one validated asthma control tool (the Asthma Control Questionnaire), which includes spirometry, functions just as well without including spirometry.¹³

In summary, this study has shown that patients with well-controlled asthma were likely to maintain this status over time, whereas patients with very poorly controlled asthma were at a particularly high risk of not achieving control and of experiencing subsequent exacerbations. Improvement in control on follow-up surveys was associated with improved asthma outcomes compared with patients who do not improve. Future studies will

be necessary to confirm these patterns over time in other samples of patients with asthma and to show that interventions in patients with uncontrolled asthma, especially if very poorly controlled, actually improve asthma control and asthma outcomes over time.

REFERENCES

1. National Asthma Education and Prevention Program. Expert Panel Report 3. Guidelines for the diagnosis and management of asthma. Summary Report 2007. *J Allergy Clin Immunol* 2007;120:S93-138.
2. Schatz M. Predictors of asthma control: What can we modify? *Curr Opin Allergy Clin Immunol* 2012;12:263-8.
3. Schatz M, Zeiger RS, Drane A, Harden K, Cibildak A, Oosterman JE, et al. Reliability and predictive validity of the Asthma Control Test administered by telephone calls using speech recognition technology. *J Allergy Clin Immunol* 2007;119:336-43.
4. Sato R, Tomita K, Sano H, Ichihashi H, Yamagata S, Sano A, et al. The strategy for predicting future exacerbations of asthma using a combination of the Asthma Control Test and lung function test. *J Asthma* 2009;46:677-82.
5. Schatz M, Zeiger RS, Yang S-J, Chen W, Crawford W, Sajjan S, et al. The relationship of asthma impairment determined by psychometric tools to future asthma exacerbations. *Chest* 2012;141:66-72.
6. Sullivan SD, Rasouliyan L, Russo PA, Kamath T, Chipps BE; TENOR Study Group. Extent, patterns, and burden of uncontrolled disease in severe or difficult-to-treat asthma. *Allergy* 2007;62:126-33.
7. Covar RA, Szefer SJ, Zeiger RS, Sorkness CA, Moss M, Mauger DT, et al. Factors associated with asthma exacerbations during a long-term clinical trial of controller medications in children. *J Allergy Clin Immunol* 2008;122:741-7.
8. Schatz M, Zeiger RS, Zhang F, Chen W, Camargo CA Jr. Overweight/obesity and risk of seasonal asthma exacerbations. *J Allergy Clin Immunol Pract*. September 27, 2013 [Epub ahead of print].
9. Schatz M, Mosen DM, Kosinsky M, Vollmer WM, Magid DJ, O'Connor E, et al. Predictors of asthma control in a random sample of asthmatic patients. *J Asthma* 2007;44:341-5.
10. Laforest L, Van Ganse E, Devouassoux G, Chretien S, Osman L, Bauguil G, et al. Management of asthma in patients supervised by primary care physicians or by specialists. *Eur Respir J* 2006;27:42-50.
11. Cloutier MM, Schatz M, Castro M, Clark N, Kelly HW, Mangione-Smith R, et al. Asthma outcomes: composite scores of asthma control. *J Allergy Clin Immunol* 2012;129(Suppl):S24-33.
12. Schatz M, Zeiger RS, Yang S-J, Chen W, Crawford WW, Sajjan SG, et al. Persistent asthma defined using HEDIS versus survey criteria. *Am J Manag Care* 2010;16:e281-8.
13. Juniper EF, O'Byrne PM, Roberts JN. Measuring asthma control in group studies: do we need airway caliber and rescue β_2 -agonist use? *Res Med* 2001;95:319-23.