

Original article

Reliability and predictive validity of the Asthma Control Test™ administered by telephone calls using speech recognition technology

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Background: The Asthma Control Test (ACT) has been validated in a paper and pencil version but has not been validated for use by telephone.

Objective: The purpose of this study was to provide validation data for the ACT administered by interactive telephone calls using speech recognition technology.

Methods: The ACT was administered to patients who confirmed a diagnosis of physician-diagnosed asthma, and information regarding race/ethnicity, smoking, and asthma course was also obtained during the call. Asthma emergency department visits, hospitalizations, and oral corticosteroid and β -agonist canister dispensings were assessed for the 12 months after the date of each patient's call. Internal consistency reliability and predictive validity were assessed.

Results: Asthma Control Test scores (higher indicates better control) were completed by 2244 patients and were inversely related to black or Hispanic race/ethnicity and smoking.

Reliability was 0.83. ACT scores were significantly related to emergency hospital care and oral corticosteroid and β -agonist dispensings over the period of the subsequent 6 and 12 months. After adjusting for demographic characteristics, a score ≤ 15 was associated significantly with an increased 12-month risk of emergency hospital care (odds ratio [OR], 2.5), oral corticosteroid dispensings (OR, 2.6) and dispensing of more than 6 β -agonist canisters (OR, 6.8) compared with a score ≥ 20 .

Conclusion: These data support the reliability and predictive validity of the ACT administered by interactive telephone calls using speech recognition technology.

Clinical implications: The ACT can be used for outreach or follow-up by means of interactive telephone calls using speech recognition technology. (*J Allergy Clin Immunol* 114:1016-1022, 2005.)

Key words: Asthma, asthma control, Asthma Control Test, asthma utilization, telephone follow-up, speech-recognition technology

Asthma is a common chronic illness that can cause substantial morbidity.¹ The goals of asthma treatment include prevention of troublesome daytime and nighttime symptoms and activity limitation because of asthma.² Asthma control has been defined as the degree to which these treatment goals are being achieved.³ However, no gold standard measure of asthma control is universally accepted, and surveys from several countries have shown that the recommended goals of asthma treatment are frequently not being accomplished.⁴

In an attempt to measure asthma control better as a guide to therapy,⁵ several validated tools have been developed.⁶⁻⁸ All of these tools ask about symptom frequency, interference with sleep, and activity limitation because of asthma and have been shown to reflect accurately the construct of asthma control.⁶⁻⁸ One of these tools, the Asthma Control Test™ (ACT; QualityMetric Corporation, Lincoln, RI), is a 5-question survey that has been shown to predict accurately the asthma specialist's assessment of asthma control on the basis of history, physician examination, and spirometry.^{8,9}

The ACT has been validated only in patients completing written forms in the clinic. However, it has been reported that only about one third of patients with asthma attend an annual review, and nonattendees may have considerable morbidity.¹⁰ Thus, to improve access to care in a patient-centered manner, there has been recent interest in telephone-assisted management of asthma.¹¹⁻¹³ Although the studies referenced were from the United Kingdom, we thought a telephone approach could be very applicable to members of our San Diego Kaiser Permanente health plan, because more than one third of our patients with asthma who are not adequately controlled on the basis of their β -agonist canister dispensings (>6 in past year)¹⁴ have not made a visit to their asthma provider in the past year (M. Schatz, unpublished data, April 2006). Moreover, we found that only 7% of our San Diego

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Supported by an unrestricted grant from GlaxoSmithKline.

Disclosure of potential conflict of interest: M. Schatz has received grant support from GlaxoSmithKline and Sanofi-Aventis and has received honoraria for talks from AstraZeneca, Merck, GlaxoSmithKline, and Genentech. R. S. Zeiger has consulting arrangements with Aerocrine, AstraZeneca, Genentech, GlaxoSmithKline, Merck, Novartis, and Sanofi-Aventis and has received grant support from AstraZeneca, GlaxoSmithKline, Merck, Sanofi-Aventis, and TEVA Pharmaceuticals. A. Drane, A. Cibildak, and J. E. Oosterman all own stock in and are employed by Eliza Corp ISO. The other authors have declared that they have no conflict of interest.

Received for publication July 10, 2006; revised August 24, 2006; accepted for publication August 29, 2006.

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0091-6749/\$32.00

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doi:10.1016/j.jaci.2006.08.042

Abbreviations used

ACT: Asthma Control Test
 CMH: Cochran-Mantel-Haenszel
 ED: Emergency department
 HEDIS: Health Plan Employer Data and Information Set
 ICD-9: International Classification of Diseases, Ninth Revision

Kaiser Permanente patients with asthma who had received 12 or more β -agonist canisters in the previous year wanted to participate in a care management program involving monthly visits.¹⁵ Because it would be more convenient, less time-consuming, and less expensive, we believe that asthma control assessment by telephone would potentially reach a larger number of patients with uncontrolled asthma. This would facilitate targeted outreach to more higher-risk patients and asthma care intervention by telephone or in person. Such outreach and intervention could be particularly useful for managed care organizations, and could also be useful for individual physicians who wish to follow their patients with asthma more closely without requiring in-person visits.

Although live calls could be used for the telephone assessment of asthma control, interactive telephone outreach using speech recognition technology appears to be a cost-effective approach. This approach has been applied to the assessment of a number of medical conditions, including diabetes, coronary artery disease, congestive heart failure, hypertension, and depression (A. Drane, unpublished data, August 2006), although published data are sparse.¹⁶ In addition to lower cost per call, the perceived anonymity offered by speech-enabled outreach may elicit more honest responses around healthcare issues.¹⁷

The purpose of this study is to provide reliability and validation information for the ACT administered to a large population of patients with asthma through interactive telephone-based outreach using speech recognition technology. Specifically, we have tested internal consistency reliability, predictive validity (of subsequent health care utilization), and convergent validity. We thought that our population was particularly suited for such a study because of its size, real-world setting, and the availability of administrative data to confirm utilization.

METHODS

Patients

Patients were members of the San Diego asthma database as of August 2004. The criteria for membership in this database were 1 year of continuous membership and 1 or more of the following in the previous 12 months:

- Any discharge diagnosis (principal or other diagnosis) of asthma in the hospitalization database (International Classification of Diseases, Ninth Revision [ICD-9] code: 493.xx)
- Two or more asthma-related medication dispensings (excluding oral steroids) in the prescription database, including β -agonists

(excluding oral terbutaline), inhaled steroids, other inhaled anti-inflammatory drugs, and oral leukotriene modifiers

- Emergency department (ED) or regular clinic asthma-related visit appointment in the diagnosis and procedures database

Patients age 18 to 56 were chosen for this study to meet the age criteria in the adult population with asthma established by the Health Plan Employer Data and Information Set (HEDIS).¹⁸ This age range decreases the proportion of patients with chronic obstructive pulmonary disease. This study was approved by the Southern California Kaiser Permanente Institutional Review Board.

Telephone calls

Calls were made between October 9 and December 31, 2004. In September 2004, eligible patients were sent a letter informing them of the study and giving them the option to opt out by returning a postcard. The letter also gave them the option of calling in to a toll-free number as well as waiting to be called. To avoid confusion, when 2 or more patients were listed at the same telephone number, only 1 was called, based on sex (women called) and/or age (oldest called). This approach was arbitrary, but on the basis of previous experience with telephone-based speech recognition interactions, we thought that women and older individuals may be more engaged with their healthcare. All calls in this study were made in English. Three calls were attempted to patients who did not opt out or call in. If an answering machine was reached, a Health Insurance Portability and Accountability Act-compliant message was left to call back at the toll-free number. If someone else in the household was reached, a message was left to call back at the toll-free number. If the target patient was reached and the patient agreed to continue, the patient was told, "This call is part of our asthma care program, which is designed to support the health of our members with asthma and may be helpful for you, but to confirm, please tell me, has a doctor ever told you that you have asthma?" If the patients said "yes," the call continued to the survey. If patients said "no," they were thanked for their time and assured that their names would be removed from this program's contact list.

Survey questions

The 5-question validated ACT survey⁸ was adapted for telephone administration as shown in Table I. The major adaptations involved providing 2-stage response choices for questions 2 to 4 to allow easier auditory comprehension of the response options. The telephone call survey also obtained the following information: (1) current smoking, (2) race/ethnicity (white, black, Hispanic, other), and (3) recent course of asthma, asking the following question: "Would you say the control of your asthma is improving, staying the same, or getting worse?" If the response was "improving," the follow-up question was, "Would you say 'much better' or 'a little better'?" If the response was "getting worse," the follow-up question was, "Would you say 'much worse' or 'a little worse'?"

Utilization information

For each patient who completed the ACT, the following information was obtained from computerized records for the 12 months before the study and for the 12 months after the date of the completed call:

- Hospitalization at Kaiser Permanente or an outside hospital with a primary diagnosis of asthma (ICD-9 code 493.XX)
- Emergency department visit at Kaiser Permanente or an outside hospital with a primary diagnosis of asthma (ICD-9 code 493.xx)
- Number of canisters of short-acting β -agonists dispensed (picked up by the patient)
- Number of dispensings of oral corticosteroids

TABLE I. ACT as administered on telephone calls using speech recognition technology (instructions: “For each of the following questions, please base your answers on how you have been feeling in the past month”)

Question	Scoring
<i>How much of the time did your asthma keep you from getting as much done at work or at home? Please answer using one of the following: none of the time, a little of the time, some of the time, most of the time, all of the time.</i>	1 = All of the time 2 = Most of the time 3 = Some of the time 4 = A little of the time 5 = None of the time
<i>During the past 4 weeks, how often have you had shortness of breath? Not at all, on a weekly basis, or every day. Follow-up to “on a weekly basis” is “Would you say more than three times a week?” Follow-up to “every day” is “Would you say more than once a day?”</i>	1 = More than once a day 2 = Daily 3 = More than 3 times a week (but not daily) 4 = Weekly (less than 3 times a week) 5 = Not at all
<i>How often did your asthma symptoms (wheezing, coughing, shortness of breath, chest tightness or pain) wake you up at night, or earlier than usual in the morning? Not at all, once or twice, or on a weekly basis. Follow-up to “on a weekly basis” is “About how many nights a week have you been waking up at night, or earlier in the morning?” Please say, once per week, 2 to 3 nights per week, or more than 4 nights per week.</i>	1 = More than 4 nights per week 2 = 2-3 nights per week 3 = Once a week 4 = Once or twice (in the past month) 5 = Not at all
<i>How often have you used your rescue inhaler or nebulizer medication (such as albuterol)? Not at all, a few times, on a weekly basis, or every day. Follow-up to “every day” is “Would you say 3 or more times per day?”</i>	1 = 3 or more times per day 2 = Every day (less than 3 times per day) 3 = On a weekly basis 4 = A few times (in the past month) 5 = Not at all (in the past month)
<i>How would you rate your asthma control during the past 4 weeks? Please say one of the following responses: completely controlled, well controlled, somewhat controlled, poorly controlled, or not controlled at all.</i>	1 = Not controlled at all 2 = Poorly controlled 3 = Somewhat controlled 4 = Well controlled 5 = Completely controlled

In addition, for the 12 months before the study, the number of controller asthma medications dispensed was captured as canisters (inhaled corticosteroids, cromolyn, nedocromil, long-acting β -agonists) or dispensings (leukotriene modifiers).

Asthma severity

To evaluate the asthma severity of the sample, the following markers were assessed for the 12 months before the study:

- Any asthma ED visit or hospitalization
- Any oral corticosteroid dispensing
- Number of β -agonist canisters dispensed
- Persistent asthma, defined similarly to the HEDIS definition of persistent asthma¹⁸ as an asthma ED visit or hospitalization or 4 or more canisters/dispensings of medications, including β -agonists and controllers (as defined)

This definition of persistent asthma differs from the HEDIS definition by not including outpatient visit criteria, because outpatient visits for asthma were not available in this data set. However, this modified definition misses less than 1% of HEDIS patients who would be included on the basis of outpatient visit criteria alone.¹⁹

Data analysis

To address possible selection bias, demographic and severity characteristics of patients completing the telephone ACT and achieving scores were compared with patients for whom a completed score was not available using χ^2 (categorical outcome) or Wilcoxon (continuous outcome) hypothesis testing. Internal consistency reliability of ACT scores was tested using Cronbach α .

Asthma Control Test score was expressed as a continuous variable or as a 3-level variable (5-15, 16-19, 20-25), as previously defined,⁹ where higher scores indicate better control. The relationship of ACT scores to demographic characteristics and recent course were tested by χ^2 (categorical variables), Wilcoxon (continuous variables compared between 2 groups), or Kruskal-Wallis (continuous variables compared between more than 2 groups) analyses. These were considered potential measures of convergent validity, the relationship of a tool to information it does not measure directly but to which it should be related.²⁰

The main approach to validity testing in this study was predictive validity, the ability of a tool to predict future events to which it should be related.²⁰ The relationships of ACT scores (continuous or as a 3-level variable) to subsequent emergency hospital care (defined as 1 or more asthma hospitalizations or ED visits as a yes/no variable), any oral corticosteroid dispensings, and number of short-acting β -agonist dispensings over the period of the following 6 and 12 months were evaluated with hypothesis testing as described. β -Agonist dispensings were evaluated as a continuous variable; dichotomized at 6 canisters, because dispensing of more than 6 canisters of β -agonist per year has been associated with an increased risk of health care utilization in other populations^{19,21}; and as a 4-level variable previously validated to reflect long-term asthma control.¹⁴ To determine whether the predictive ability of the ACT was influenced by baseline asthma severity (persistent versus not persistent), stratified analyses were conducted controlling for persistent versus nonpersistent baseline severity using Cochran-Mantel-Haenszel (CMH) statistics. The relationships between ACT scores and subsequent medical utilization were adjusted for demographic characteristics by using multiple logistic regression analyses.

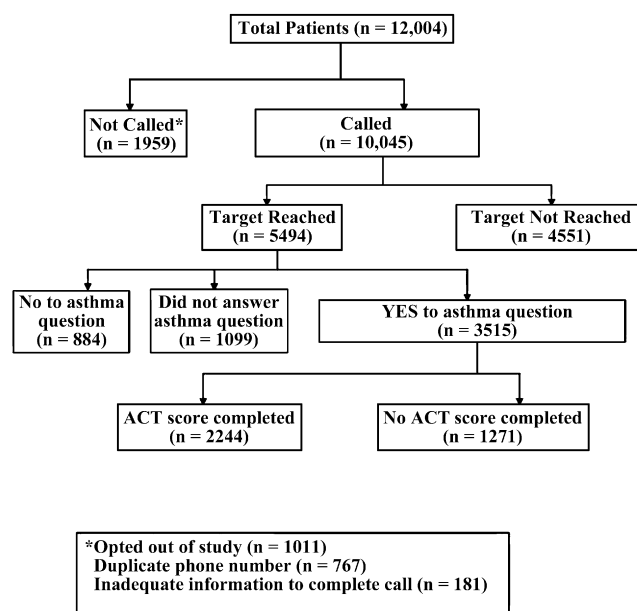


FIG 1. Call outcomes of study subjects.

Nominal statistical significance was set at .05. All analyses were performed using SAS statistical software (SAS Version 8.2 for Windows; SAS Institute Inc, Cary, NC).

RESULTS

A total of 12,004 patients were identified who met the study criteria from the San Diego Kaiser Permanente asthma database. Of those, 1011 (8.4%) opted out of the study, and 10,045 (83.7%) were called (Fig 1). Of those called, 5494 target patients (54.7%) were reached, and 3515 (64.0%) of those stayed on the call and confirmed a diagnosis of physician-diagnosed asthma. An ACT score was completed in 2244, which represented 18.7% of total patients and 63.8% of the reached patients with a confirmed physician diagnosis of asthma (Fig 1).

Patients who completed the call and produced an ACT score were older and more likely to be women than patients who did not produce a score (Table II). Patients who produced a score were somewhat more likely to have required emergency hospital care in the previous year ($P > .05$) and significantly more likely to receive oral corticosteroids than patients who did not produce a score (Table I). β -Agonist dispensings during the previous year were similar between groups (Table I).

Reliability (Cronbach α) for the ACT survey in this sample was 0.83. There was a trend toward poorer control in older patients and no significant sex differences in asthma control in this sample (Table III). Black and Hispanic patients had lower ACT scores than white and other patients, and smokers reported significantly lower ACT scores than nonsmokers (Table III). There was a significant relationship between patient-reported recent course of asthma and ACT scores, with the most

TABLE II. Previous year characteristics of patients with versus without a completed ACT score

Characteristic	Score (n = 2244)	No score (n = 9760)
Age		
Mean $\pm$ SD	42.1 $\pm$ 10.7*	39.4 $\pm$ 11.3
Median (IQR)	45 (35-51)*	41 (30-49)
Female sex (%)	75.8*	63.7
ED visit/hospitalization (%)	2.7	2.4
Oral steroid use (%)	27.6*	23.0
Mean $\pm$ SD β -agonist canisters/year dispensed	3.3 $\pm$ 4.3	3.4 $\pm$ 4.7
Persistent asthma (%)†	59.0*	48.9

* $P < .05$ between groups (Wilcoxon for age and β -agonist use, χ^2 for other).

†See text for definition.

pronounced differences between patients with worse or much worse course compared with those with same, better, or much better course (Table III).

Asthma Control Test scores were significantly related to the occurrence of emergency hospital care in the following 6 months, with a weaker but still significant relationship to such care in the second 6 months after the date the ACT score was obtained (Table IV). The relationship of ACT scores to subsequent oral corticosteroid use was strong for both the first and second 6 months after the ACT survey (Table IV). There was a significant negative correlation ($P < .0001$) between ACT scores and the number of β -agonist canisters dispensed over the next 3 ($r = -0.32$), 6 ($r = -0.35$), and 12 ($r = -0.35$) months. A highly significant relationship was also observed between ACT scores and the previously validated β -agonist long-term control scale¹⁸ (Table IV).

TABLE III. Relationship of ACT scores to demographic characteristics and perceived recent course (n = 2244)

Characteristic (%)	Mean $\pm$ SD ACT	% ACT ≥ 20	% ACT 16-19	% ACT ≤ 15
Age				
< Median* (40.4)	19.7 $\pm$ 4.1	60.9	22.5	16.6
$\geq$ Median* (59.6)	19.4 $\pm$ 4.4	57.6	22.8	19.6
P value	.11†		.06§	
Sex				
Female (75.8)	19.6 $\pm$ 4.3	59.0	22.9	18.1
Male (24.2)	19.4 $\pm$ 4.4	58.5	22.1	19.5
P value	.51†		.60§	
Race/ethnicity				
White (73.0)	19.6 $\pm$ 4.2	60.5	21.7	17.8
Black (7.5)	18.7 $\pm$ 4.4	51.3	26.0	22.7
Hispanic (12.5)	18.9 $\pm$ 4.5	50.8	27.6	21.6
Other (7.0)	20.0 $\pm$ 4.2	58.6	23.6	17.9
P value	.002‡		.05§	
Smoking				
No (90.1)	19.9 $\pm$ 4.3	60.5	22.0	17.5
Yes (9.9)	18.9 $\pm$ 4.3	45.9	27.7	26.4
P value	<.0001†		<.0001§	
Course				
Much better (19.8)	21.7 $\pm$ 3.4	81.4	11.8	6.8
Better (7.8)	18.1 $\pm$ 3.9	42.2	34.9	22.9
Same (64.2)	19.7 $\pm$ 4.0	60.0	24.5	15.5
Worse (6.5)	15.0 $\pm$ 3.6	10.7	31.4	57.9
Much worse (1.7)	10.9 $\pm$ 3.0	0.0	8.3	91.7
P value	<.0001‡		<.0001§	

*For total sample.

†Wilcoxon.

‡Kruskal-Wallis.

§ χ^2 .

The ACT scores expressed as a 3-level variable were significantly related to the next 12 months' emergency hospital care, oral corticosteroid dispensings, and higher β -agonist canister dispensings (Table V). Analyses stratified for baseline severity (persistent versus nonpersistent) revealed significant relationships between ACT scores and the next 12 months' emergency hospital care (CMH $P = .005$), oral corticosteroid dispensings (CMH $P < .0001$), and higher β -agonist dispensing (CMH $P < .0001$; data not shown). After adjustment for demographics, patients with ACT scores ≤ 15 were more than twice as likely to require emergency hospital care, 2½ times more likely to receive a course of oral corticosteroids, and nearly 7 times more likely to receive more than 6 β -agonist canisters in the following year compared with patients with a score ≥ 20 (Table V). Patients with scores between 16 and 19 were 70% more likely than patients with scores ≥ 20 to require oral corticosteroids and more than 2½ times more likely to receive more than 6 β -agonist canisters in the following year (Table V).

DISCUSSION

Asthma assessment and management by telephone has been reported to increase the proportion of patients whose

TABLE IV. Relationship of ACT scores to future utilization

Utilization	Mean $\pm$ SD ACT	% ACT ≥ 20	% ACT 16-19	% ACT ≤ 15
Asthma ED visit or hospitalization 1st 6 months				
Yes (n = 18)	15.9 $\pm$ 5.6	27.8	22.2	50.0
No (n = 2226)	19.6 $\pm$ 4.3	59.2	22.7	18.2
P value	.004†		.0006§	
Asthma ED visit or hospitalization 2nd 6 months				
Yes (n = 68)	18.3 $\pm$ 4.8	48.5	19.1	32.4
No (n = 2176)	19.4 $\pm$ 4.3	59.2	22.8	18.0
P value	.038†		.009§	
Steroids 1st 6 months				
Yes (n = 205)	17.8 $\pm$ 4.6	42.9	25.9	31.2
No (n = 2039)	19.7 $\pm$ 4.2	60.5	22.4	17.1
P value	<.0001†		<.0001§	
Steroids 2nd 6 months				
Yes (n = 258)	17.7 $\pm$ 4.7	42.3	27.5	30.2
No (n = 1986)	19.8 $\pm$ 4.2	61.1	22.0	16.9
P value	<.0001†		<.0001§	
β -Agonist scale*				
0-2 (n = 1538)	20.4 $\pm$ 3.9	66.6	19.9	13.5
3-6 (n = 436)	18.7 $\pm$ 4.1	50.2	28.7	21.0
7-12 (n = 177)	16.8 $\pm$ 4.1	33.3	27.7	39.0
>12 (n = 82)	15.0 $\pm$ 5.1	20.7	31.7	47.6
P value	<.0001‡		<.0001§	

*Short-acting β -agonist canister dispensings in a 12-month period, as previously validated¹⁴; missing β -agonist data for 11 patients.

†Wilcoxon.

‡Kruskal-Wallis.

§ χ^2 .**TABLE V.** Relationship of 3-level ACT scores to future utilization, bivariate and adjusted for demographic characteristics*

12-Month outcome/ACT level	Percent of cohort with outcome	Adjusted odds ratio (95% CI)
ED/hospital		
≥ 20 (n = 1322)	2.9	Reference
16-19 (n = 509)	3.3	1.0 (0.6-1.9)
≤ 15 (n = 413)	7.0	2.2 (1.3-3.7)
Oral steroids		
≥ 20 (n = 1322)	12.8	Reference
16-19 (n = 509)	20.2	1.7 (1.3-2.3)
≤ 15 (n = 413)	27.6	2.6 (1.9-3.5)
β -Agonist > 6†		
≥ 20 (n = 1320)	5.8	Reference
16-19 (n = 506)	15.1	3.1 (2.2-4.5)
≤ 15 (n = 403)	27.6	6.8 (4.8-9.5)

*Multiple logistic regression; adjusted for age, sex, race/ethnicity, and smoking; area under the receiver operating characteristic curves (c statistic) 0.65 for ED/hospital, 0.63 for oral steroids, and 0.74 for β -agonists >6.†Missing β -agonist data for 11 patients.

asthma status was reviewed and reduce the cost per clinical encounter without compromising asthma control, quality of life, or patient satisfaction.¹¹⁻¹³ The goal of asthma therapy is asthma control, and accurate assessment of asthma control is critical to improving it.⁵ Good asthma control implies symptoms or rescue therapy use less than

3 times per week, interference with sleep less than 3 times per month, and no limitation of activity, and step therapy is recommended to achieve these goals.^{2,5} A valid telephone assessment of asthma control would permit effective asthma outreach and interventions, such as stepping up therapy, by telephone. This study provides the first reliability and predictive validation data for an asthma control tool administered by telephone. Patients with ACT scores determined by telephone to be ≤ 15 were more than twice as likely to require emergency hospital care, 2½ times more likely to receive a course of oral corticosteroids, and nearly 7 times more likely to receive more than 6 β -agonist canisters in the following year compared with patients with a score ≥ 20 (Table V). The inverse relationship demonstrated in the current study between telephone call-determined ACT scores and smoking and black race (Table III), as previously reported for the paper and pencil version of the ACT,²² as well as the strong relationship of ACT scores with patient-described asthma course (Table III) provide convergent validity²⁰ data for the telephone version of the ACT. Strengths of this study include its real-world setting, large sample size, and objective measures of utilization.

Studies using the paper and pencil version of the ACT have demonstrated its reliability, criterion validity, convergent validity, and responsiveness to change.^{8,9} No predictive validity data have been previously presented for the ACT. Studies have shown that the Asthma Therapy Assessment Questionnaire, another asthma control tool, is related to subsequent health care utilization.^{23,24} The ACT cutoffs used in this study were derived from the paper and pencil longitudinal validation study,⁹ but their validity was confirmed for the telephone version in the current study.

Because one of the questions of the ACT deals specifically with β -agonist use (Table I), it may not be surprising that there is a strong relationship between the ACT and subsequent β -agonist use over the next 3, 6, or 12 months. However, this does not lessen the importance of identifying patients at increased risk for higher levels of β -agonist use over the coming year. ACT scores predicted subsequent β -agonist use defined on a scale that has been shown to be related to asthma quality of life, symptom severity, and health care utilization.¹⁴

Because the telephone ACT predicts subsequent health care utilization, it would appear to be particularly valuable as an outreach tool for managed care organizations. However, because it also correlates with markers of quality of life, symptom severity, and asthma course, it could be useful for both managed care organizations and individual physicians as a way, without an in-person visit, to assess more frequently and conveniently the status of their patients with asthma and facilitate intervention if indicated.

This study administered the telephone calls using speech recognition technology, as has been applied to the assessment and management of a wide range of conditions such as diabetes, hypertension, congestive heart failure, depression, and asthma (A. Drane,

unpublished data, August 2006). Using such technology has been shown to be more cost effective than live calls, at least for large numbers of calls, because the cost of interviewer time is greater than the cost of speech recognition technology script preparation (A. Drane, unpublished data, June 2006). In addition, speech-enabled calls provide the ability to reach more patients in a shorter period while ensuring consistency of message and traceability and eliminating the need for manual data entry. Some studies show that the perceived anonymity—such as the kind offered by speech-enabled outreach—elicits more honest responses around healthcare issues.¹⁷ We assume that administration of the ACT by live interviewer calls would be just as valid as it was shown to be in this study using the speech-enabled calls as long as the same script was used (Table I). However, only a similar study of the ACT administered using live calls could prove that assumption.

Completed ACT scores were obtained for 19% of the total number of eligible patients (Fig 1). This was apparently a result of many factors. Interactive telephone calls using speech recognition technology is a rather unconventional method of interaction with the healthcare system for most people, and one might expect the response rate to improve as interactive telephone calls using speech recognition technology become more widespread in the healthcare industry. The increased likelihood of scores being obtained in women may speak to their increased telephone availability, although the preferential calling of women when 2 patients with the same number were encountered may explain some of this discrepancy as well. Because patients with scores appeared to have more severe asthma than patients without scores, on the basis of previous steroid requirements and the prevalence of persistent disease (Table II), patients with less severe asthma may have been less interested in participating because they felt they had less to gain. However, patients with more severe asthma are generally less well controlled and represent a cohort of patients with asthma with greatest utilization and cost, and thus one in which intervention may have the greatest effect and benefit. The response rate may also be increased in the future by further optimizing the survey tool for administration by telephone and by using personal physician names or voices on the call.

It is of interest that 25% of targets reached did not confirm physician-diagnosed asthma. Although the reasons for this could be either poor understanding by the patient or false-positives of the electronic database asthma criteria, we did think it was important to test the validity of the ACT only in patients who confirmed a physician diagnosis of asthma. In future iterations of this program, people who say they do not have a diagnosis of asthma could be asked a follow-up question that assesses whether the patient has experienced wheezing, coughing, or shortness of breath. In similar studies, this approach has proven to identify as many as 40% more patients with asthma (A. Drane, unpublished data, March 2006).

Finally, completed scores were not obtained in 36% of patients who stayed on the call and confirmed a physician diagnosis of asthma, usually because the patients did not

provide understandable answers to 1 or 2 questions. We are currently exploring ways to increase the participation of patients in the calls and to reduce the number of incomplete scores in those who participate. However, the current study shows that the score is valid when completed.

An important issue is the generalizability of the current results. Although patients with completed scores were older and more likely to be women than patients without scores, the results were adjusted for these characteristics. Patients with scores were more likely to have persistent asthma, but the relationship between ACT scores and subsequent utilization persisted after controlling for persistent versus nonpersistent asthma. The study was performed in primarily white patients, but 20% of patients were black or Hispanic, and the results were adjusted for race/ethnicity. However, all participants in this study were English-speaking, and similar studies using other languages will be necessary to confirm the language generalizability of these results. All patients in this study were members of the Kaiser Permanente Health Plan. Although it seems likely that the current results would generalize to patients with other sources of health care, that can only be proven by additional studies in such patients.

This study does have some potential limitations. Although it provides evidence of internal consistency reliability and predictive and convergent validity of the ACT administered by telephone, it does not evaluate test-retest reliability or responsiveness or shed light on the comparability of ACT scores administered by telephone calls using speech recognition technology versus paper and pencil administration. Future studies are planned to evaluate these properties. The current study did not include objective measures, such as spirometry, to both confirm the diagnosis of asthma and assess pulmonary physiological outcomes. However, regarding diagnosis, this study used physician-diagnosed asthma as the criterion, which has been shown to be a valid way to identify patients with asthma in epidemiologic studies.²⁵ Regarding outcomes, we feel that the absence of spirometry is acceptable because the ACT predicts asthma control as determined by a specialist evaluation better than does the FEV₁,⁸ and it has been recently shown that the Asthma Control Questionnaire, another validated asthma control tool that initially included FEV₁, performs just as well without the FEV₁.²⁶ Finally, dispensing of medication does not automatically equate to use of medication, although pharmacy records are being recommended as a method of assessing patient adherence.^{27,28}

It is important to recognize that questionnaires that have been designed and tested in pencil-and-paper format may not necessarily be optimized for speech-enabled outreach. With this in mind, it may be necessary to adjust the way the questions are asked or the response choices, while ideally not altering the content or validity, when adapting paper and pencil tools for voice-enabled telephone administration. There would appear to be several apparent benefits of using speech-enabled, telephone-based outreach to administer questionnaires such as the one used in this paper. For instance, the vast majority of American

households have telephone access, helping to increase the number of reachable members. Speech is an easy-to-use interface that requires no end-user training and carries no literacy requirements, and by its very nature yields faster turnaround times than traditional pencil-and-paper questionnaires. In addition, speech recognition technology is able to capture entire member interactions and facilitate data analysis and reporting at the member level.

In summary, this study provides support for the reliability and validity of the ACT when administered by telephone using speech recognition technology. It is hoped that further studies will confirm these findings and demonstrate the usefulness of telephone assessments using the ACT for outreach or clinical follow-up to improve asthma outcomes in both managed care and individual practice settings.

We thank Elaine Jenson for her clerical help with this study. Melody Khalaj, application developer at Eliza Corp, also contributed to this study.

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