

Validation of Asthma Control Assessment Among Urban Adolescents Using the Asthma Control and Communication Instrument



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What is already known about this topic? The National Institutes of Health guidelines recommend questionnaires to assess asthma control, but there are few validated questionnaires among urban, African American, Hispanic, and/or poor adolescents.

What does this article add to our knowledge? The results of this study support the validity of the Asthma Control and Communication Instrument as a self-reported measure of impairment from asthma among urban, African American, Hispanic, and/or poor adolescents.

How does this study impact current management guidelines? The Asthma Control and Communication Instrument can be used by various health care providers to easily and accurately measure asthma control in adolescent populations. It is already valid for use among diverse adult populations.

BACKGROUND: The National Institutes of Health guidelines recommend questionnaires to assess asthma control, but there are few self-reported asthma morbidity surveys validated among urban, African American, Hispanic, and/or poor adolescents. The Asthma Control and Communication Instrument (ACCI) is a 12-item self-reported questionnaire previously validated among a diverse adult population, but not among adolescents. **OBJECTIVE:** To assess the ability of the ACCI to accurately describe asthma control in an urban adolescent population. **METHODS:** Between November 13, 2014, and March 2, 2017, we collected information using the ACCI, the Asthma Control Test, the Pediatric Asthma Quality of Life Questionnaire, and lung function among adolescents enrolled in a school-based asthma intervention study. The ACCI measure of asthma control was validated by evaluating accuracy (on the basis of receiver operating characteristic curve), internal reliability, and concurrent and discriminative validity.

RESULTS: We collected information on 280 adolescents (mean age, 13.4 years; 56% males; and 51% African American). ACCI control showed good internal reliability and strong concurrent and discriminative validity with the Asthma Control Test and the Pediatric Asthma Quality of Life Questionnaire. The accuracy of the ACCI in classifying adolescents with uncontrolled asthma was good (area under the curve, 0.83; 95% CI, 0.79-0.88).

CONCLUSION: The ACCI, a clinical tool developed to assist communication about asthma control, has demonstrated strong construct validity as a self-reported questionnaire within an urban, African American, and Hispanic sample of adolescents. It has the potential to assist in the assessment of asthma control in urban, minority, and/or poor adolescents. © 2018 Published by Elsevier Inc. on behalf of the American Academy of Allergy, Asthma & Immunology (J Allergy Clin Immunol Pract 2019;7:962-8)

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INTRODUCTION

National asthma guidelines from the National Institutes of Health (NIH) encourage the use of validated questionnaires by clinicians.¹ However, even though a number of published adult asthma questionnaires have included adolescents in their validation studies,²⁻⁴ the representation is frequently low and no validation studies have focused exclusively on adolescents. In addition, those studies frequently underrepresent individuals of urban settings, racial/ethnic minority backgrounds, and/or low socioeconomic status. These populations are important to study because they are less likely to receive the preventive asthma care recommended by NIH guidelines, they experience higher rates of

Abbreviations used

ACCI- Asthma Control and Communication Instrument
ACT- Asthma Control Test
ED- emergency department
EPR-3- third Expert Panel Report
FENO- fractional exhaled nitric oxide
FVC- forced vital capacity
NIH- National Institutes of Health
PAQLQ- Pediatric Asthma Quality of Life Questionnaire
PCP- primary care provider
SFDs- symptom-free days

acute health care use for asthma,⁵⁻⁷ and they are underrepresented in clinical research.⁸ There are also other experiences (eg, discrimination and stress) that directly and/or indirectly negatively affect asthma care and outcomes in these populations.⁹⁻¹¹

There are a number of pediatric questionnaires, but these rely primarily on parental report.¹²⁻¹⁴ It may be more accurate and developmentally appropriate for adolescents to self-report. Furthermore, many pediatric asthma surveys share similar limitations in their validity testing as the adult asthma questionnaires outlined earlier.

The Asthma Control and Communication Instrument (ACCI) is a questionnaire previously validated by 1 of the authors (S.O.O.) for use among adult, urban, and diverse patients with asthma.¹⁵ The ACCI was designed to facilitate the outpatient evaluation of asthma control, risk, adherence, and patient-provider communication to assist clinicians in asthma management of adults. However, the ACCI has not been validated as a self-report questionnaire among adolescents. The purpose of this study was to assess the ability of the ACCI to accurately describe asthma control among a diverse urban adolescent population.

METHODS

Procedures

Parent study: School-Based Asthma Care for Teens is an ongoing study to evaluate the widespread implementation of a developmentally appropriate preventive asthma care intervention for urban adolescents. This program includes 2 core components: (1) a trial of directly observed therapy to allow the teen to experience the potential benefits from adhering to guideline-based asthma treatment and (2) a developmentally appropriate motivational interviewing counseling intervention to help the teen transition to independent long-term medication adherence. Symptomatic children (aged 12-16 years) with doctor-diagnosed asthma and persistent or uncontrolled symptoms as per caregiver report, who were attending school in the Rochester City School District, were identified through school-based screening. Exclusion criteria included inability to speak and understand English, complex medical history that could interfere with asthma assessments, and lack of telephone access. We scheduled home visits for interested teens and caregivers so as to obtain informed consent/assent and to conduct the baseline measurements. Participants were then randomly assigned to 1 of 3 treatment groups. Informed consent from all caregivers and assent from adolescent participants were obtained. Subjects were followed for a year for outcome measures as part of the parent study, but the focus of the current analysis is baseline data collected at enrollment. A baseline survey, including the aforementioned measures, was administered at

home by a research assistant. Baseline data collection occurred between November 13, 2014, and March 2, 2017. In this study, because we do not have objective adherence data on patient medication use, the focus is on assessment of the control categories only.

Questionnaire development and content

The ACCI is written at a fifth-grade reading level and was developed after cognitive testing and vignette-based surveys of a diverse physician group. It is a 12-item self-reported questionnaire that assesses 5 conceptual domains of asthma status:

1. *direction*—perceived changes in asthma status;
2. *bother*—perceived disease burden;
3. *risk*—reports of emergency department (ED) visits, hospitalizations, and oral steroid use;
4. *adherence*—adhering to daily controller medications; and
5. *control*—frequency of daytime symptoms, short-acting β_2 agonist use, asthma attacks, activity limitation, and nocturnal symptoms (ie, guideline-based measures of impairment).

ACCI control domain

The time frame of recall for the control items is 1 week, except for nocturnal awakening, which is 2 weeks (see Figure E1 in this article's Online Repository at www.jaciinpractice.org).

Scoring the ACCI domain

As described previously, the ACCI control domain may be scored in 3 ways:

1. *Sum score* is a summation of the score assigned to each response option (0-4 for questions 7, 8, 10, and 11; 0-3 for question 9), ranging from 0 (best asthma control) to 19 (worst asthma control).
2. *Problem index* dichotomously scores each of the 5 control items as 0 (controlled) or 1 (not controlled), which are then summed, ranging from 0 (no control problems) to 5 (5 control problems).
3. *Categories* uses a classification scheme based on NIH asthma guideline assessments by categorizing patients into 4 severity/control categories (intermittent/controlled, mild persistent/partially controlled, moderate persistent/uncontrolled, and severe persistent/poorly controlled). An instruction is provided for the clinician, stating "Assign patient's current level of asthma control by looking at the box checked farthest to the right on questions 7-11 and match the box color to the level of asthma control in this section." For simplicity, 2 control categories may be used instead (controlled and not controlled). Intermittent symptoms are considered controlled, whereas persistent symptoms are not controlled.

Established asthma morbidity measures

Asthma Control Test. The Asthma Control Test (ACT) (for patients aged ≥ 12 years) is a 5-item questionnaire that assesses asthma control over the previous month.¹⁶ The total score for the ACT ranges from 5 (poor control) to 25 (complete control). A score higher than 19 indicates well-controlled asthma.

Pediatric Asthma Quality of Life Questionnaire. The Pediatric Asthma Quality of Life Questionnaire (PAQLQ)¹⁷ consists of 13 questions that assess the impact of asthma on activity limitation and emotional function during the previous week, using a 7-point scale. The final PAQLQ score is a mean of the 13 scores, with higher scores indicating better quality of life.

Symptom-free days. The measure of symptom-free days (SFDs) has been a widely used symptom measure.^{18–20} Participants were asked, “Over the past 2 weeks (*out of 14 days*) how many days did you remain *symptom-free* within a 24-hour period, including *daytime* and *nighttime*?”

Missed school days. Measuring missed school days is important because asthma is the leading cause of school absenteeism. We evaluated the number of days missed from school over the previous school year and in the past 2 weeks because of asthma.

Asthma symptoms. We used standard criteria for symptom report established in the 1997 asthma guidelines published by the third Expert Panel Report (EPR-3) of the NIH.¹ Participants reported over the preceding 4 weeks the frequency of daytime symptoms (never, twice a week or less, more than twice a week but not daily, daily but not all of the time, and every day all of the time), nocturnal sleep disruption (never, 1–2 times a month, 3–4 times a month, 1–3 times a week, 4 or more times a week, and nightly), rescue medication use (never, 2 days a week or less, more than 2 days a week but not daily, daily, and several times a day), any week with daytime symptoms more than twice in 1 week (yes or no), and need for rescue medication use more than twice in 1 week (yes or no). Participants were also asked over the previous year the frequency of asthma exacerbations that required oral corticosteroids (none, once, 2–3 times, and more than 3 times). Responses were categorized into intermittent, mild, moderate, and severe symptoms.

Health care use for asthma. Participants were asked to report the occurrence and frequency over the previous 12 months of each of the following health care events related to asthma: (1) doctor visits, (2) ED visits, (3) hospitalizations, and (4) urgent care visits.

Asthma medication use. Participants reported the frequency of use of albuterol (everyday, some days, as needed/when sick) over the previous 2 weeks and oral corticosteroids over the previous 12 months.

Spirometry. We used a portable spirometer (EasyOne Plus diagnostic spirometer, Medical Technologies, Inc., Andover, MA) to obtain 2 measures of spirometry: (1) FEV₁, expressed as a percentage of predictive values, and (2) the ratio of FEV₁ to forced vital capacity (FVC), known as the FEV₁/FVC ratio. Tests of inadequate quality were excluded from analysis.

Fractional exhaled nitric oxide. Fractional exhaled nitric oxide (FENO) was assessed using the NIOX VERO Airway Inflammation Monitor (Circassia Pharmaceuticals, Inc., Morrisville, NC) to noninvasively characterize the degree of allergic airway inflammation among study participants.

Analyses of measures of ACCI control

Means and percentages were used to describe the characteristics of the study population. Floor and ceiling effects of the ACCI sum score and the problem index scores were evaluated to see whether respondent scores were clustered at the low or high ends of these scales—such clustering would suggest that the ACCI is not useful in discriminating different levels of asthma control.^{21,22} We used Cronbach α to evaluate the internal reliability of the ACCI control domain (the 5 questions that assess daytime symptoms, rescue medication use, attacks, activity limitation, and sleep disruption). To evaluate concurrent construct validity, we evaluated the correlations between the ACCI control domain (sum score and problem index)

with (1) the ACT, (2) the PAQLQ, (3) SFDs, (4) missed school days, (5) health care use, and (6) lung function (FEV₁ as a percentage of predicted values; the FEV₁/FVC ratio, and FENO) using Spearman correlation coefficients. We hypothesized that higher ACCI control scores would correlate with worse rating of disease status as assessed by the aforementioned measures of asthma morbidity.

To test for discriminative properties, we examined mean ACT, PAQLQ, SFDs, missed school days, health care use, medication use, and lung function values across the ACCI categories (controlled to poorly controlled) and problem index (0, 1, 2, 3, 4, and 5) using ANOVA. We also calculated receiver operating characteristic curve to assess the accuracy of the ACCI control domain in identifying controlled asthma as determined by 10 or more SFDs over the previous 14 days (consistent with NIH EPR-3 criteria for well-controlled asthma), using a logistic regression model. Values more than 0.8 for areas under the receiver operating characteristic curves were considered as good levels of accuracy.²³ Stata 15.0 (StataCorp, College Station, Texas) was used for all analyses. A 2-tailed *P* value of less than .05 was used to determine significance.

RESULTS

There were a total of 280 participants (participation rate, 80%). Table I presents an overview of the participants. There was a slight predominance of male (56%) and African American (51%) participants, with a mean age of 13 years. Approximately two-thirds of the participants were classified as having uncontrolled or persistent asthma according to the ACCI, whereas a slightly lower proportion had persistent asthma on the basis of NIH criteria. A slight majority reported a visit to their primary care provider (PCP) for asthma over the previous 12 months (52%), but less than one-quarter reported an urgent care or ED visit for asthma. Few reported hospitalization for asthma (6%) during the same time period. In terms of lung function, FEV₁ and FEV₁/FVC ratio were normal on average, whereas FENO was elevated (mean, 36 parts per billion). For floor and ceiling effects of the sum score, 45 (16%) had a score of 0 and 1 (0.4%) had a score of 14. For the problem index, 212 (76%) reported no problems and 0 (0) reported all 5.

Internal reliability

The ACCI control subscale showed good internal reliability overall (Cronbach α = 0.73).

Concurrent validity

ACCI control (sum score and problem index) showed convergent construct validity, with significant correlations with the ACT, PAQLQ, SFDs, missed school days, and health care use (Table II), but not with the measures of lung function. For ACCI control, higher values represent better asthma status, which explains the direction of the correlations with the ACT, PAQLQ, and SFDs.

Discriminative validity

The ACCI categories of control (Table III) and the ACCI problem index (Table IV) also significantly discriminated between different measures of asthma morbidity. More specifically, ACT, PAQLQ, and SFD values significantly decreased across categories as ACCI categories and problem index domains worsened. We observed the same association with missed school days (over the past year and over the previous 2 weeks), PCP

TABLE I. Sociodemographic and asthma characteristics of participants (N = 280)

Characteristic	Number of participants, n (%)	Mean ± SD (min, max)
Age (y)		13.4 ± 1.1 (12, 16)
Male	156 (56)	
Medicaid	234 (84)	
Race/ethnicity		
Black	141 (51)	
Hispanic	90 (33)	
Other	22 (7)	
White	15 (5)	
Black/white	11 (4)	
ACCI score		3.7 ± 3.2 (0, 14)
ACCI index		0.4 ± 0.8 (0, 4)
ACCI levels of control		
Intermittent	93 (33)	
Mild persistent	119 (43)	
Moderate persistent	49 (18)	
Severe	19 (7)	
FEV ₁ pp (n = 243)		88.3 ± 15.3 (86.3, 90.2)
FEV ₁ /FVC (n = 243)		80.5 ± 9.0 (79.3, 81.6)
FENO		36.0 ± 37.1 (31.7, 40.4)
ACT score		19.3 ± 4.1 (6, 25)
PAQLQ		5.5 ± 1.2 (1.4, 7)
SFDs in the last 2 wk per teen		8.7 ± 4.6 (0, 14)
Days missed for asthma in last school year		3.9 ± 7.0 (0, 50)
Days missed for asthma in last 2 wk		1.2 ± 2.1 (0, 14)
Health care use for asthma in past year		
PCP visit asthma	142 (52)	
ED visit asthma	62 (23)	
Hospitalization asthma	16 (6)	
Urgent care visit	32 (12)	
Rescue medication use		
None	8 (3)	
As needed	194 (69)	
Some/daily	77 (28)	
NIH EPR-3 severity level		
Intermittent	121 (44)	
Mild	99 (36)	
Moderate	39 (14)	
Severe	19 (7)	

Note. All columns of data do not add up to 100% because of rounding. FEV₁pp, FEV₁ as a percentage of predicted values.

visits, and ED visits because of asthma. A statistically nonsignificant trend was observed with hospitalizations ($P = .10$) and urgent care visits ($P = .06$) because of asthma. No statistically significant linear trends were observed for the ACCI categories or problem index in association with lung function or FENO.

Looking at the relationship of the ACCI sum score categorized as controlled or not controlled, we observed significant differences in mean scores across categories of the various asthma morbidity indicators, including missed school days, rescue medication use, and asthma-related PCP visits, ED visits,

TABLE II. Concurrent validity of ACCI score and problem index with validated asthma morbidity indicators, using Spearman coefficient correlation

Description	ACCI problem index		ACCI score	
	ρ	P value	ρ	P value
ACT	−0.588	<.001	−0.819	<.001
PAQLQ	−0.561	<.001	−0.735	<.001
FEV ₁ % predicted	−0.021	.730	−0.110	.071
FEV ₁ /FVC	0.045	.459	−0.002	.969
FENO	0.023	.702	0.103	.086
SFDs	−0.530	<.001	−0.667	<.001
Days missed for asthma in last school year	0.231	<.001	0.228	<.001
Days missed for asthma in past 2 wk	0.468	<.001	0.435	<.001
PCP visit, asthma	0.379	<.001	0.338	<.001
ED, asthma	0.337	<.001	0.322	<.001
Hospitalization, asthma	0.161	.007	0.190	.001
Urgent care, asthma	0.329	<.001	0.214	<.001

hospitalizations, and urgent care visits (Table V). There was no significant association with lung function measurements or FENO.

Accuracy of ACCI control domain

The areas under the receiver operating characteristic curves of the ACCI sum score (0.83; 95% CI, 0.78–0.88; Fig. 1) and problem index (0.70; 95% CI, 0.65–0.75; Fig. 2) showed that the sum score more accurately predicted asthma guideline classifications of controlled asthma than the problem index.

DISCUSSION

This study demonstrates that the ACCI is a valid self-reported measure of asthma control in adolescent patients. Specifically, the ACCI: (1) effectively measures asthma control status, (2) distinguishes clinically important differences of disease status, (3) accurately categorizes asthma control compared with NIH guidelines, and (4) performs adequately in urban, African American, and Latino populations. Given the known increased morbidity and inadequate asthma care for urban, black, Hispanic, and/or low socioeconomic status children, it is important to have a validated questionnaire for use with these populations. NIH guidelines recommend use of validated questionnaires to assess asthma, so the ACCI offers a means to meet that standard for health care providers who treat adolescents with asthma.

Notably, we observed overlap in the 95% CIs of mean ACT scores across the moderate and severe ACCI categories. These findings are likely due to (1) the small number of participants classified as “severe” ($n = 19$) and (2) the definitional closeness of these 2 categories in the National Heart, Lung, and Blood Institute asthma guidelines in terms of daytime symptom and rescue medication use: patients may not fully appreciate the differences between “daily” and “throughout the day” or “several times per day” for moderate or severe persistent asthma, respectively. Notably, the difference in mean ACT and PAQLQ scores between moderate and severe asthma exceeds the minimal clinically important difference reported for both these measures—which suggests that the moderate and severe ACCI categories are distinct. In addition, we observed no overlap in 95%

TABLE III. ACCI discriminant validity: trend in mean values (95% CI) of validated asthma morbidity indicators across ACCI categories using ANOVA

Asthma morbidity indicator	ACCI levels of control				P value
	Intermittent (n = 93)	Mild (n = 119)	Moderate (n = 49)	Severe (n = 19)	
ACT	22.5 (22.0-23.1)	19.2 (18.6-19.7)	15.7 (14.7-16.7)	13.7 (11.3-16.2)	<.001
PAQLQ	6.4 (6.3-6.6)	5.5 (5.3-5.6)	4.7 (4.3-5.0)	4.0 (3.2-4.7)	<.001
FEV ₁ % predicted	90.3 (86.9-93.7)	86.8 (83.9-89.7)	85.1 (81.3-88.9)	89.4 (82.1-96.8)	.212
FEV ₁ /FVC	0.80 (0.78-0.83)	0.80 (0.78-0.82)	0.79 (0.76-0.83)	0.80 (0.80-0.87)	.600
FENO	30.9 (23.8-38.1)	39.5 (32.9-46.1)	40.3 (28.2-52.5)	28.7 (9.3-48.1)	.243
SFDs	12.1 (11.4-12.8)	8.5 (8.0-9.1)	5.1 (4.5-5.7)	3.0 (2.3-3.9)	<.001
School days missed for asthma in last school year	2.8 (2.5-3.1)	3.1 (2.8-3.5)	7.2 (6.5-8.0)	4.8 (3.9-5.9)	.001
School days missed for asthma in past 2 wk	0.2 (0.1-0.3)	0.1 (0.0-0.2)	0.8 (0.5-1.0)	1.5 (1.0-2.1)	<.001
PCP visit, asthma	1.0 (0.8-1.2)	1.0 (0.8-1.2)	3.9 (3.4-4.5)	4.3 (3.4-5.4)	<.003
ED, asthma	0.3 (0.2-0.4)	0.2 (0.2-0.3)	1.1 (0.8-1.4)	1.2 (0.7-1.8)	<.005
Hospitalization, asthma	0.1 (0.0-0.2)	0.0 (0.0-0.1)	0.2 (0.1-0.4)	0.3 (0.1-0.6)	.120
Urgent care, asthma	0.1 (0.0-0.2)	0.1 (0.0-0.2)	0.2 (0.1-0.4)	0.2 (0.0-0.5)	.059

TABLE IV. ACCI problem index discriminant validity: trend in mean values (95% CIs) of asthma morbidity indicators across ACCI problem index values using ANOVA

Asthma morbidity indicator	ACCI problem index						P value
	0 (n = 212)	1 (n = 40)	2 (n = 18)	3 (n = 8)	4 (n = 2)	5 (n = 0)	
ACT score	20.6 (20.2 to 21.1)	16.1 (14.9 to 17.3)	15.3 (13.5 to 17.2)	12.3 (9.3 to 15.2)	7.5 (1.1 to 13.9)	—	<.001
PACQLQ score	5.7 (5.5 to 5.9)	5.5 (4.9 to 6.0)	4.4 (3.5 to 5.3)	5.3 (4.1 to 6.6)	3.8 (−5.8 to 13.3)	—	.005
FEV ₁ /FVC	0.8 (0.8 to 0.8)	0.8 (0.8 to 0.8)	0.8 (0.8 to 0.9)	0.8 (0.7 to 0.9)	0.8 (0.4 to 1.3)	—	.728
FEV ₁ % predicted	88.3 (86.1 to 90.5)	85.9 (81.3 to 90.6)	86.0 (79.5 to 92.5)	83.4 (75.8 to 91.0)	108.0 (69.9 to 146.1)	—	.293
FENO, continuous	35.7 (30.9 to 40.6)	38.4 (25.7 to 51.1)	31.7 (10.4 to 52.9)	31.8 (1.4 to 62.1)	80.5 (−853.4 to 1014.4)	—	.496
SFDs	10.1 (9.6 to 10.6)	5.7 (4.5 to 7.0)	2.8 (1.2 to 4.5)	3.1 (0.4 to 5.9)	0.0 (0.0 to 0.0)	—	<.001
School days missed for asthma in last school year	3.0 (2.3 to 3.7)	6.5 (3.2 to 9.7)	4.8 (0.4 to 9.2)	7.5 (−3.6 to 18.6)	20.0 (20.0 to 20.0)	—	<.001
School days missed for asthma in past 2 wk	0.1 (0.0 to 0.2)	0.5 (0.2 to 0.8)	1.2 (0.2 to 2.3)	1.5 (−0.2 to 3.2)	5.0 (5.0 to 5.0)	—	<.001
PCP visits for asthma	1.0 (0.7 to 1.3)	3.0 (1.7 to 4.4)	5.4 (0.4 to 10.5)	2.9 (1.5 to 4.2)	15.5 (−16.3 to 47.3)	—	<.001
ED visits for asthma	0.2 (0.1 to 0.3)	0.9 (0.3 to 1.6)	1.2 (0.5 to 1.9)	0.9 (−0.5 to 2.2)	5.0 (−58.5 to 68.5)	—	<.001
Hospitalizations for asthma	0.1 (0.0 to 0.1)	0.1 (0.0 to 0.2)	0.6 (−0.1 to 1.2)	0.3 (−0.3 to 0.8)	0.0 (0.0 to 0.0)	—	.004
Urgent care visits for asthma	0.1 (0.1 to 0.2)	0.1 (0.0 to 0.3)	1.4 (0.2 to 2.7)	0.0 (0.0 to 0.0)	7.5 (−87.8 to 102.8)	—	<.001

CIs between the moderate and severe ACCI categories for SFDs or missed school days. Collectively, these findings suggest that the ACCI moderate and severe asthma categories are valid. Conversely, there did appear to be a floor effect for the ACCI problem index, but not the sum score. Given that at baseline, 44% of patients met NIH EPR-3 criteria for intermittent asthma, the findings for the problem index floor are not surprising—it is not uncommon for patients to improve in symptom control after enrollment into research studies.²⁴ Consistent with this floor effect observation, the problem index was not as accurate as the sum score in identifying controlled asthma. Therefore, it appears that the sum score is a more robust measure than the problem index.

Given the limited number of asthma questionnaires validated among adolescents, the ACCI fills an important void. First,

pediatric questionnaires rely on parental report, which may be less reliable in adolescents. Second, studies of adult asthma questionnaires often have small or nonexistent adolescent populations.^{16,25} Third, in conjunction with the pediatric ACCI,²⁶ the ACCI offers the clinician a questionnaire useable by all NIH age groups: 4 years old and younger, 5 to 11 years old, and 12 years and older. We also acknowledge that there are strategies being developed (eg, the use of endotypes) that may offer more specific identification of asthma subgroups for targeted treatment options to optimize outcomes.^{27,28}

We did not observe a significant association of the ACCI control with lung function. However, lung function correlates poorly with symptoms,^{29,30} quality of life,¹⁷ and airway inflammation.³¹ Therefore, lung function (spirometry and FENO) may be a distinct construct from asthma control.

TABLE V. Discriminative validity: trend in ACCI sum scores across asthma morbidity measures using ANOVA (Wilcoxon rank sum for variables with 2 categories)

Morbidity measure	ACCI score, mean (95% CI)	P value
ACT		<.0001
Controlled	1.7 (1.4-1.9)	
Uncontrolled	6.0 (5.5-6.6)	
School days missed in last year*		<.0001
No	3.1 (3.1-4.2)	
Yes	7.2 (6.0-8.4)	
PCP visit		<.001
No	2.9 (2.4-3.2)	
Yes	4.5 (3.9-5.0)	
ED visit		<.0001
No	3.3 (2.9-3.7)	
Yes	5.1 (4.2-6.0)	
Hospitalization		<.001
No	3.5 (3.1-3.9)	
Yes	6.6 (4.8-8.3)	
Urgent care visit*		.002
No	3.4 (3.0-3.8)	
Yes	5.3 (3.9-6.6)	
Rescue medication use		<.001
None	2.9 (1.8-3.9)	
As needed	3.2 (2.8-3.6)	
Some/daily	4.9 (4.1-5.7)	
FEV ₁ pp categories		.08
≥100%	3.0 (2.2-3.9)	
<100%	3.8 (3.4-4.2)	
FEV ₁ /FVC categories		.80
≥80%	3.6 (3.1-4.1)	
<80%	3.7 (3.1-4.3)	
FENO categories		.20
≤50 (not high)	3.6 (3.1-4.0)	
>50 (high)	4.0 (3.2-4.8)	
NHLBI categories		<.001
Intermittent	1.7 (1.4-2.0)	
Mild	4.3 (3.7-4.9)	
Moderate	6.2 (5.1-7.3)	
Severe	7.5 (5.8-9.3)	

FEV₁pp, FEV₁ as a percentage of predicted values; NHLBI, National Heart, Lung, and Blood Institute.

*Asthma-related occurrences only.

There are several limitations to this study. First, these results may not be generalizable to children receiving care in nonurban settings. However, this limitation is common across publicly available asthma questionnaires, and we included a high-risk, but understudied, population. Furthermore, this sociodemographic group is reflective of most US children. Second, we used teen self-reported data gathered during the first half of the school year (during recruitment), raising the possibility of reporting bias. However, we would expect that any reporting bias is nondifferential across self-reported questionnaires and toward the null. Furthermore, self-report is a standard method for obtaining information in a clinical setting. Third, we relied on comparisons with other survey instruments that have

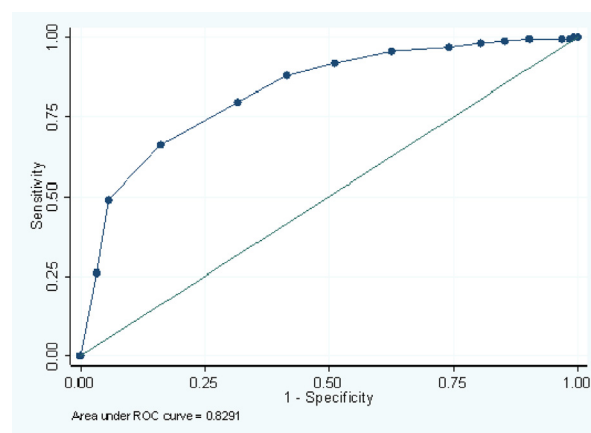


FIGURE 1. Accuracy of ACCI sum score to identify controlled asthma (controlled asthma as defined by 10 or more SFDs). ROC, Receiver operating characteristic.

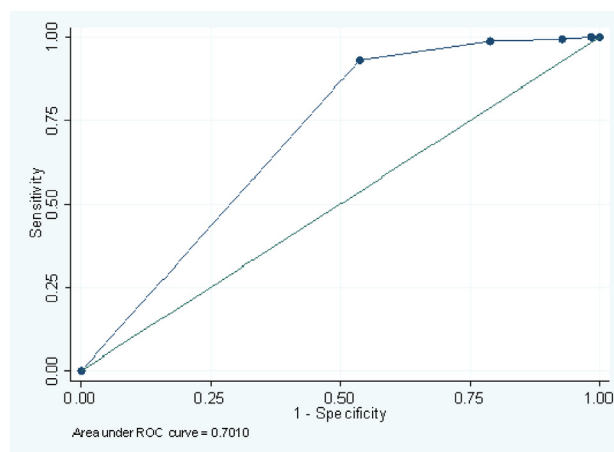


FIGURE 2. Accuracy of ACCI problem index to identify controlled asthma (controlled asthma as defined by 10 or more SFDs). ROC, Receiver operating characteristic.

limited evidence in our study population.^{24,32} However, we view the consistency of the ACCI results with these other surveys as an indicator of validity. Fourth, there may be concerns about the level of insight that adolescents have regarding their asthma, but the mean age at diagnosis was 3.4 ± 3.5 years, whereas the mean duration of diagnosis was 10.0 ± 3.6 years, indicating a reasonable duration of time dealing with asthma by these participants. Finally, as with other questionnaires, we do not know the impact of routine use of the ACCI on asthma care and outcomes.

CONCLUSIONS

We found the ACCI to be an accurate measure of asthma control in an adolescent urban, African American, and/or Latino population. The ACCI can help to standardize asthma care and to present understandable, useable information in diverse adolescent populations.

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Asthma Symptoms											
1. Over the <i>past week</i>, how many days have you had asthma symptoms? For example: ▪ Cough ▪ Chest tightness ▪ Shortness of breath ▪ Sputum (spit, mucous, phlegm when coughing) ▪ Difficulty taking a deep breath ▪ Wheezy or whistling sound in the chest	Days <table style="width: 100%; text-align: center;"> <tr> <td>0</td> <td>1-2</td> <td>3-6</td> <td>Every day (not all day long)</td> <td>Every day (all day long)</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>	0	1-2	3-6	Every day (not all day long)	Every day (all day long)					
0	1-2	3-6	Every day (not all day long)	Every day (all day long)							
Reliever use											
2. Over the <i>past week</i>, how many days have you had to use medicine to quickly relieve asthma symptoms? For example: ▪ Albuterol/Proventil/Proair/Ventolin/Xopenex via inhaler/spray/pump or machine/nebulizer	Days <table style="width: 100%; text-align: center;"> <tr> <td>0</td> <td>1-2</td> <td>3-6</td> <td>Every day (not all day long)</td> <td>Every day (all day long)</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>	0	1-2	3-6	Every day (not all day long)	Every day (all day long)					
0	1-2	3-6	Every day (not all day long)	Every day (all day long)							
Attacks											
3. Over the <i>past week</i>, how many days did you have an asthma attack? For example: ▪ When it is harder to breathe for your child ▪ When you give your child more quick-relief asthma medicine (eg, albuterol) ▪ When the asthma medicine does not work	Days <table style="width: 100%; text-align: center;"> <tr> <td>0</td> <td>1</td> <td>2-3</td> <td>4-7</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> </tr> </table>	0	1	2-3	4-7						
0	1	2-3	4-7								
Activity Limitation											
4. Over the <i>past week</i>, how much did your asthma limit your activities?	Activity Limitation <table style="width: 100%; text-align: center;"> <tr> <td>Not at all</td> <td>Slightly</td> <td>Moderately</td> <td>Very much</td> <td>Completely</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>	Not at all	Slightly	Moderately	Very much	Completely					
Not at all	Slightly	Moderately	Very much	Completely							
Nighttime Symptoms											
5. Over the <i>past 2 wk</i>, how many nights did your asthma keep you from sleeping or wake you up?	Nights <table style="width: 100%; text-align: center;"> <tr> <td>0</td> <td>1</td> <td>2</td> <td>3-7</td> <td>8-14</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>	0	1	2	3-7	8-14					
0	1	2	3-7	8-14							
12. Please write down any concerns or anything else you would like your doctor to know about your child's asthma.											

PLEASE GIVE THIS TO YOUR PROVIDER. Thank you.

FOR CLINICIAN USE ONLY: Control/Severity Assignment				
	Controlled/ Intermittent	Partly Controlled/ Mild Persistent	Uncontrolled/ Moderate Persistent	Poorly Controlled/ Severe Persistent
Assign patient's current level of asthma control/severity by looking at the box checked <i>farthest to the right</i> on questions 7-11 and match the box color to the level of asthma control/severity in this section. <i>Severity</i> categories are for patients <i>not on controller therapy</i>. <i>Control</i> categories are for patients <i>currently taking controller therapy</i>. The <i>goal for all patients</i> is to have <i>controlled</i> asthma with the least amount of medication and no side effects. If asthma is <i>not controlled</i>, possible explanations include acute respiratory tract infection, undertreatment with daily controller medications, poor inhaler technique, poor adherence, environmental allergies and/or exposures, and comorbid conditions (see treatment algorithm on page 3). Follow-up in 2-6 weeks is recommended.				

FIGURE E1. Items of the teen ACCI control domain.