

Relations among asthma knowledge, treatment adherence, and outcome

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Background: Asthma knowledge is frequently assumed to be a prerequisite for optimal asthma treatment. However, the validity of existing asthma knowledge questionnaires has not been rigorously examined, and no contemporary measure of asthma knowledge has received widespread acceptance.

Objective: To construct and examine the psychometric properties of an asthma knowledge instrument, and its association with demographic and psychosocial variables, asthma medication adherence, and treatment outcome.

Methods: A 25-item Asthma Knowledge Questionnaire was developed with input from national pediatric asthma experts. Parents of 155 children with asthma completed the Asthma Knowledge Questionnaire as well as demographic, family functioning, and home environment measures. Asthma outcomes and adherence with inhaled medication was measured across 12 months.

Results: Despite the many steps taken to develop a strong measure of asthma knowledge, reliability was relatively poor.

There was also no association between asthma knowledge and treatment adherence or outcomes. Furthermore, asthma knowledge was not a unidimensional construct and was not a simple function of education.

Conclusions: Findings from this study, in combination with previous studies of asthma knowledge questionnaires, suggest that the construction of a simple self-report asthma knowledge instrument for use as a primary outcome measure demonstrating mastery of asthma self-management skills may not be achievable. (*J Allergy Clin Immunol* 2003;111:498-502.)

Key words: Asthma knowledge, treatment adherence, asthma outcomes

The assumption that a basic understanding of asthma pathophysiology and treatment is essential for children and their parents to most effectively treat pediatric asthma is widely held and explicit within the Expert Panel Guidelines.¹ From this perspective, the assessment and promotion of asthma knowledge becomes a key task for health care providers and researchers. A number of prior questionnaires have been developed to assess asthma knowledge. However, most of the existing knowledge questionnaires are outdated because they were constructed before the emphasis on inflammation as the central problem in

Abbreviations used

DPS: Denver Public Schools

HMO: Health maintenance organization

MDI: Metered-dose inhaler

NCICAS: National Cooperative Inner-City Asthma Study

SES: Socioeconomic status

asthma.^{2,3} Existing measures of asthma knowledge are also compromised by content inconsistent with current asthma care guidelines, inadequate psychometric validation, or small or inadequately characterized subject samples.^{4,5} For example, one of the more widely used asthma knowledge questionnaires had reproducibility analyses performed on only 12 respondents.² The Asthma Information Quiz developed by the National Cooperative Inner-City Asthma Study (NCICAS) was one of the stronger contemporary efforts in measure development, yet no psychometric properties have been reported to date.⁶

The current study was conducted to assess the capacity of a new instrument to measure asthma knowledge and to examine the construct of asthma knowledge, including its relation to objectively measured asthma management behavior.

METHODS

Participants

All subjects participated in a large longitudinal study of family influences on childhood asthma treatment adherence and outcome. The research protocol was reviewed and approved by the National Jewish Institutional Review Board. Informed consent/assent was obtained from all participating parents and children. Subjects were recruited from two sources. These sources were selected to provide informative contrasts: the Public School sample to be more reflective of the "average" level of asthma care in metro Denver; the Health Maintenance sample to reflect a population for which a comprehensive system-level plan for treating asthma is in effect.

Denver Public Schools subsample. Seventy-six children with mild to moderate severity asthma were recruited from 10 of the 53 Denver Public Schools (DPS) elementary schools to participate in this study. These 10 schools were chosen on the basis of proximity to our institution and a desire to maximize racial/ethnic diversity. Eligible subjects were identified through the use of health status records collected during school registration. All subjects received daily scheduled asthma medications from their primary health care provider. Children were excluded if they had another active pulmonary disease, ≥ 6 oral steroid bursts, or ≥ 2 hospitalizations in the prior year or prior intubation for asthma. Furthermore, to verify their diagnosis of asthma, all children in the DPS sample needed to

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demonstrate reversibility >10% on prebronchodilator and postbronchodilator spirometry upon study entry.

Health Maintenance Organization subsample. Eighty children were recruited from the computerized medical records of the Colorado Kaiser Permanente Health Maintenance Organization (HMO). Children were 7 to 16 years of age, had been prescribed an inhaled steroid within the past 6 months, and had made at least 1 visit to an allergist for asthma during the past year. Medical records of all participants were reviewed under the supervision of a Kaiser allergist to verify the diagnosis of asthma (by criteria of reversible airway obstruction or bronchial hyperresponsivity). The Asthma Knowledge Questionnaire was missing for 1 child, resulting in a final sample size of 79 children.

The total sample included 155 children, ranging in age from 7 to 17 years (mean 10.5; SD = 2.2), of whom 57% were boys. Thirty-five percent of the children were of racial/ethnic minority group (3% Asian, 17% Hispanic, and 15% black). The sample was well distributed across socioeconomic status⁷ (SES; class I = 11.8%, class II = 39.9%, class III = 27.4%, class IV = 11.8%, and class V = 9.1%). The DPS and HMO subsamples did not differ in child age and sex. However, there were significantly more children of racial/ethnic minority groups and from lower SES backgrounds in the DPS compared with the HMO subsample. These differences in race/ethnicity and SES were controlled for in all subsequent comparisons across these subsamples.

Procedure

Research visits were scheduled at times convenient to the subjects. The questionnaires listed below were completed by the child's parent in a quiet room separated from their child, who was occupied with other research tasks.

The Asthma Knowledge Questionnaire. This instrument was constructed to measure components of parental asthma knowledge particularly relevant for pediatric asthma management, including knowledge about symptoms, triggers, and interventions. Some items were developed by a multidisciplinary panel and some were adapted from previously published questionnaires.^{2,3} A large initial pool of items was assembled, with items being discarded or replaced on the basis of input from nationally recognized experts in pediatric asthma (including members of the Child Asthma Management Program Executive Committee). Efforts were made to reflect the latest Expert Panel Guidelines.¹ The measure was designed not to reflect the contents of any particular asthma education curriculum but instead to quantify adequacy of practical asthma knowledge in a clinical or research context. The final 25-item Asthma Knowledge Questionnaire can be seen in Table I and was rated at a grade 6.7 reading level.

Demographic information. Demographic information including the child's sex, race, and age and parental SES (ie, education and occupation status levels⁷) was collected from each family.

Home Environment Questionnaire. Parents were asked questions regarding the presence or absence of different household allergens/irritants.^{8,9} Households were considered to contain smokers if it was reported that a parent, the asthmatic child, any other household member, or any regular visitor used any tobacco product.

The Family Assessment Device General Functioning Scale. This 12-item, self-reported measure of general family functioning was completed by parents and children and has been shown to have acceptable psychometric properties.¹⁰⁻¹²

Functional Severity of Asthma Scale. This 6-item scale measures the influence of asthma on the daily functioning of school-aged children.¹³ Reliability is good (Cronbach α = 0.89), and validity is supported by correlations with school days missed, resource utilization, and medication use.

Health care utilization. At regularly scheduled follow-up visits, parents were asked to provide information about medication use, hospitalizations, emergency room visits, physician visits, and school absence. This information was summed into utilization estimates across the 12 months from study entry.

Asthma medication adherence. The DoserCT (Meditrack, Hudson, Mass), secured to the top of the child's prescribed anti-inflammatory metered-dose inhaler (MDI), internally recorded the number of daily activations for a period of 45 days while providing no visual feedback to the subject. Subjects were informed that the Doser kept track of daily medication use and were asked to sign an agreement confirming that they would use only the Doser-equipped MDI. Every 2 months, used Dosers were collected from the patient and their information was downloaded, and replacement Doser-equipped MDIs were provided. This was done for DPS participants at follow-up visits every 2 months and at follow-up visits every 4 months for Kaiser participants supplemented by exchange of Dosers through the mail every 2 months between these visits. To mimic the situation for the HMO subjects and to eliminate cost as a reason for poor adherence, subjects in the DPS sample were provided their controller MDIs free of charge throughout the study. MDI adherence across time was calculated as a mean percent adherence across all 12 months provided that a subject had at least 3 "valid" adherence measurements out of the possible 6. Reasons for "invalid" adherence measurements included Doser failure and nonreturn of Doser. With the use of these conventions, mean MDI adherence estimates were obtained for 60 DPS subjects and 69 HMO subjects.

Statistical analyses

Data were analyzed with JMP v3.2.6 software (Cary, NC). The internal consistency of the asthma knowledge questionnaire was estimated by calculating Cronbach α . This reliability statistic measures the degree to which a set of questionnaire items assesses a single unidimensional latent construct. A principle components analysis of the questionnaire items was also run as another test of the dimensionality of the knowledge questionnaire. Finding a large first factor that explains a majority of the variance in the set of items is support for unidimensionality. Pearson correlation coefficients were used to examine the association of asthma knowledge with continuous variables, and *t* test tests were used for analyses of knowledge with categorical variables. Stepwise regression techniques were used to determine which set of correlates best predict asthma knowledge. Tests were 2-tailed (α = 0.05).

RESULTS

Psychometric properties

Table I includes the 25 Asthma Knowledge Questionnaire items and their correct response rates. For 9 of the 25 questions, 95% or more of the parents gave the correct response. The mean parental knowledge score for this sample was 88% correct (SD = 10.5%; range = 52% to 100%).

Internal consistency reliability was low but adequate (Cronbach α = 0.69), providing marginal support that asthma knowledge as measured by this questionnaire was unidimensional. On the other hand, a principle component analysis yielded 9 "significant" factors (ie, with an eigenvalue >1), accounting for 63.4% of the overall variance. The first factor explained only 15.4% of the overall variance, strongly arguing against unidimensionality.

As seen in Fig 1, several findings support the validity of this instrument. Parents of children from the HMO group, who routinely receive systematic asthma educa-

TABLE I. Percent of respondents providing a correct answer

Item	Correct response	Percent correct (n = 140–155)
1. Coughing is not a symptom of asthma.	F	77%
2. Asthma is due to inflammation in the lungs.	T	88%
3. Smoking in the home can make a child's asthma worse.	T	99%
4. Asthma attacks can happen when you breathe things like paint fumes, gasoline, smoke, or pollution.	T	99%
5. Keeping an asthma attack from happening is something only a doctor can do.	F	99%
6. If you start to have an asthma attack, you might notice a tight feeling in your chest before wheezing starts.	T	95%
7. A peak flowmeter is used to make sure your sinuses are open.	F	94%
8. If asthma symptoms such as tightness and wheezing do not occur for several years, a child has outgrown his/her asthma.	F	89%
9. Asthma is an emotional or psychological disease.	F	87%
10. Most children with asthma have to go to the hospital for asthma attacks.	F	86%
11. For some people, asthma becomes less severe as they get older.	T	89%
12. Doctors are not really sure why some people have asthma, but they know what can start an attack.	T	83%
13. With appropriate treatment, most children with asthma should lead a normal life with no restrictions on activities.	T	99%
14. Anger, crying, or laughing can start an asthma attack.	T	82%
15. If you don't have asthma by the time you are 40 years old, you will never get it.	F	97%
16. Children with asthma should not play sports in which they have to run a lot.	F	95%
17. In young children, asthma sometimes starts after a viral respiratory illness.	T	92%
18. An allergen is the antibody missing in people with asthma.	F	83%
19. It is possible for your asthma to be worse without noticing a change in your breathing.	T	75%
20. Exercising in cold weather can start an asthma attack.	T	93%
21. Fish and birds are both good pets for a child with asthma.	F	64%
22. A rescue inhaler (ie, bronchodilator) is taken to reduce inflammation in the lungs.	F	31%
23. Some asthma medications don't work unless you take them every day.	T	92%
24. You don't need to shake most asthma medication inhalers before using them.	F	97%
25. Fewer people have asthma today than 10 years ago.	F	95%

tion as a result of referral to an asthma specialist, had significantly higher mean asthma knowledge scores (and lower variance) than parents of children from the DPS group. Given that the differences between DPS and HMO may have been due to factors other than the receipt of systematic asthma education, possible group differences with regard to family and demographic variables were examined with the finding that DPS had lower SES, lower full-scale child IQ, higher racial/ethnic minority representation, and more severe asthma than the HMO group. However, the differences in asthma knowledge between the DPS and HMO groups remained significant even after controlling for the above possible confounds, adding more support that the observed differences were due to differential receipt of systematic education.

In addition, children who lived in a household in which there was at least one smoker had parents with significantly lower knowledge scores than children who lived in a nonsmoking household. Also, children receiving suboptimal treatment when evaluated according to the Expert Panel Guidelines¹ (eg, only bronchodilator treatment for persistent asthma) had parents with significantly lower asthma knowledge than children who received appropriate treatment.

Despite this evidence of validity, the Asthma Knowledge Questionnaire failed to predict important behaviors related to self-management, including medication adher-

ence or disease-related outcomes. Asthma knowledge was not correlated with the 12-month average level of medication adherence as measured by the electronic Doser (see Fig 2). Analyses of asthma outcome variables revealed that knowledge was not associated with any 12-month asthma outcome, including functional severity score, number of doctor and ER visits, and the number of missed school days.

We performed an item analysis to examine the possibility that medication adherence might be more strongly associated with those items that inquired about medication knowledge. Item 21, "fish and birds are both good pets for a child with asthma," was the only item strongly associated with adherence ($P < .001$).

Relations between asthma knowledge and psychosocial characteristics

As seen in Table II, analyses of demographic characteristics of study participants revealed that higher asthma knowledge scores were associated with higher level of parent education, race (white versus nonwhite), higher SES, and child-reported family functioning. Child age, child sex, and parent-reported family functioning were not associated with parent's asthma knowledge.

To further understand the correlates of asthma knowledge, a multiple regression analysis was conducted with asthma knowledge as the dependent variable and child

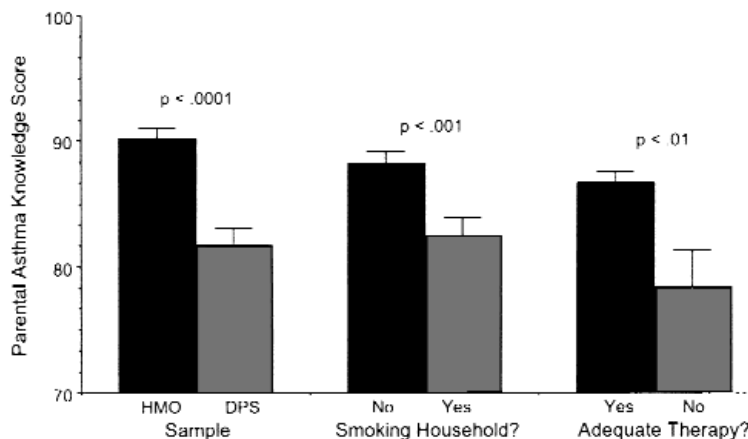


FIG 1. Differences emerged after controlling for potential confounding factors including race, education, socioeconomic status, child IQ, and asthma severity.

age, sex, and race, parent education level, household smoking, and child-reported family functioning as independent variables. The overall regression model was significant ($R^2 = 0.31$, $P < .0001$), with parent education, white race, and child-reported family functioning as significant independent predictors of asthma knowledge.

DISCUSSION

The Asthma Knowledge Questionnaire was carefully developed, drawing on previously published measures, using a panel of nationally recognized experts in pediatric asthma, and incorporating the latest practice guidelines for childhood asthma. Despite these efforts, the results suggest that the questionnaire's reliability was adequate at best. Most importantly, no association was found between scores on the questionnaire and treatment adherence or outcome. This finding suggests a problem with construct validity, as the assumption that knowledge directly leads to improved day-to-day, self-management behaviors and health outcomes was not supported. Despite the temptation to use a simple paper-and-pencil questionnaire to evaluate the role of knowledge in asthma outcomes, there appears to be little to no justification for doing so.

The finding of no association between knowledge and treatment adherence or outcomes is consistent with a meta-analysis that examined 11 controlled asthma education trials and concluded that asthma education programs had little impact on asthma outcome including school absenteeism, attack frequency, and ER/hospital utilization.¹⁴ Furthermore, the Asthma Information Quiz developed as part of the NCICAS was unrelated to parents' practical applied knowledge about how to make hypothetical asthma management decisions and child outcomes, including wheezing and functional status.^{6,15} At best, this suggests that if any relations exist among knowledge, behavior, and outcome, they are complex.

Our results revealed several specific weaknesses of paper-and-pencil asthma knowledge measures. First, factor analysis demonstrated that asthma knowledge is not a

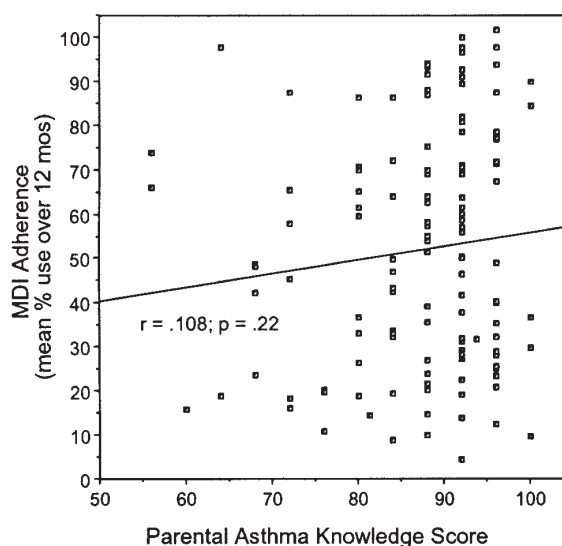


FIG 2. Association of asthma treatment adherence with asthma knowledge.

single, unified dimension. A similar factor analytic result was found in a recent attempt to develop an adult asthma knowledge questionnaire.¹⁶ Future efforts to develop an asthma knowledge questionnaire need to consider that asthma knowledge may be multidimensional, for example, different knowledge may be needed to know when to take controller medication versus avoid triggers. In support of this notion, a recent report demonstrated that adherence with inhaled anti-inflammatory medication was not associated with either household smoking or pet ownership, suggesting that not only knowledge but asthma adherence may be multidimensional.¹⁷

Second, human performance factors such as inattentiveness or lack of engagement with the task may explain the borderline reliability that we observed. In another recent study, approximately 30% of adults gave inconsistent responses on two logically incompatible questions of asthma knowledge.¹⁸ Future research could examine

TABLE II. Correlation of asthma knowledge with demographic and family variables (n = 155)

	Mean (SD)	Correlation	Statistic	P value
Demographics				
Child				
Age		-.06		NS
Sex				
Male	86.4 (1.1)			
Female	85.5 (1.3)		-0.57	NS
Race				
White	89.2 (0.9)			
Nonwhite	80.1 (1.3)		-5.66	<.0001
Parent				
Maximum parent education		.46		<.0000
Hollingshead SES		.42		<.0000
General Family Functioning				
Parent reported		-.08		NS
Child reported		-.22		<.006

whether tests of knowledge trigger different response biases in respondents, for example, lower perceived relevance or greater perceived threat, than other questionnaires, for example, those measuring quality of life.

Finally, the regression analyses suggest that asthma knowledge is not a simple function of asthma education. Rather, asthma knowledge appears to be related to a number of factors, including an assortment of personal factors and community resources, such as parental education level, white race, and general family functioning. This embedment of knowledge in a sociocultural web also is consistent with several recent reports.^{19,20} The association between asthma knowledge and appropriate treatment suggests the possibility of a physician factor. That is, patients whose physicians provide asthma care consistent with current guidelines may also keep their patients better informed about asthma and its treatment.

Taken together, these results suggest a need to reevaluate current conceptions of asthma knowledge because asthma knowledge as measured by a paper-and-pencil questionnaire is not a unitary phenomenon, is affected by complex sociodemographic factors, and is not associated with treatment adherence and outcomes. Future efforts at constructing a measure of asthma knowledge need to take into account this complexity. For example, asthma knowledge may be best assessed through more practical and behaviorally focused observations such as responses to vignettes or real-life scenarios.²¹ It is possible that a different questionnaire, perhaps using more sensitive questions (eg, multiple choice or more relevant questions) and focusing on use of asthma medications, might better correlate with asthma self-management behaviors. However, given the constantly changing body of information about pharmacologic intervention and the failure of any asthma questionnaire to predict behavior, this

seems unlikely. Available evidence indicates that knowledge is only an important prerequisite to successful self-management. Lacking the capacity to assess motivation or behavioral competency, it is improbable that any knowledge questionnaire can substitute as a measure of actual self-management practices.

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