

An exploration of factors underlying asthma care and morbidity: A factor analysis of clinical variables

Thomas P. Miller, MD,^a Frederick L. Oswald, PhD,^b and Mathew J. Reeves, PhD^a East Lansing, Mich

Background: Clinical risk models use recognized risk factors to identify patients at risk for future asthma morbidity. However, the low predictive values of these models suggest an important need to re-evaluate risk assessment strategies.

Objective: To use exploratory factor analysis to define underlying factors operative in asthma treatment and morbidity, and characterize their interrelationships and association with 6-month morbidity.

Methods: Children (n = 197) presenting to an emergency department for an acute asthma episode were followed for 6 months (follow-up data available for 84%). Baseline data included demographics, asthma history, current and past symptoms, and current treatment and management. Factor analysis was used to summarize the underlying relationships between variables. Correlations between factors and 6-month morbidity were calculated.

Results: Factor analysis revealed that 4 factors provided a parsimonious summary of the variables. The factors were labeled *current symptom severity*, *quality of care indicators*, *previous severe disease*, and *sociodemographic factors*. Positive correlations were observed between quality of care, current symptom severity, and previous severe disease. The factor describing sociodemographic factors was inversely related to current symptom severity and quality of care. Previous severe disease significantly predicted 6-month morbidity.

Conclusion: Quality of care was better in subjects with increased current symptoms or previous severe disease, but poorer in individuals with adverse sociodemographic factors. Previous severe disease was the only factor associated with 6-month morbidity, suggesting that current assessment methods do not adequately account for all underlying factors likely operative in asthma morbidity. (*J Allergy Clin Immunol* 2008;122:328-34.)

Key words: Asthma, factor analysis, emergency department, quality of care

Asthma continues to be a significant burden to individuals and societies.^{1,2} Various risk factors have been identified as being associated with future asthma morbidity, including previous

Abbreviations used

CSS: Current symptom severity
ED: Emergency department
PSD: Previous severe disease
QOC: Quality of care
SDF: Sociodemographic factors
SMM: Six-month morbidity

hospitalizations or emergency department (ED) visits, higher β -agonist dependence, and lower use of inhaled steroids.³⁻¹⁵ Specific clinical guidelines have been promoted to increase asthma control and decrease morbidity.^{16,17} Despite these recommendations, health care utilization rates for asthma continue to be high.¹⁸ Current asthma clinical risk models have consistently low predictive values,^{19,20} despite being based on recognized morbidity risk factors. This disparity between the clinical risk literature and the actual risk of asthma exacerbations suggests the need to re-evaluate current research and practice strategies.

The effectiveness of asthma treatment strategies is dependent on many variables; some are disease-specific (eg, degree of airflow obstruction, allergic phenotype, or the relative responsiveness to steroids, and so forth), whereas others are not (eg, socioeconomic status, psychosocial factors, and so forth). This complexity of interactions, observed in biologic systems, has been one of the elements that has prompted the development of systems biology.²¹ Systems biology takes a broad perspective by attempting to integrate all of the various elements that affect the functioning of a given cell or protein. A goal of systems biology is to be able to model the whole system adequately to predict the response to perturbations. One of the features of a biologic system includes *context dependency* (ie, the functioning of molecules or cells is dependent on the specific molecular or cellular context). All elements that affect asthma control and outcomes taken together form the *context of disease*. By attempting to incorporate the entire context of disease (all relevant variables) in analyses, we will likely develop a better understanding of the disease itself, and a more accurate causal model for asthma morbidity. In an effort to explore current clinical practice and its association with morbidity, this study uses factor analysis to identify factors that underlie the observed variables commonly used in clinical asthma care, and examines the association with 6-month morbidity in a prospective cohort of children with asthma. As a secondary goal, this study demonstrates a methodology to account for a broader context of disease as it is reflected in common clinical practice.

Factor analysis techniques may not be familiar to many clinicians; we provide a description of the essentials, but detailed discussions of these techniques can be found in a variety of textbooks.^{22,23} Factor analysis is an empirical method for summarizing relationships between a large set of measured variables.

From ^athe College of Human Medicine and ^bthe Department of Psychology, Michigan State University.

Disclosure of potential conflict of interest: F. L. Oswald has received research support from Navy Personnel Research Studies and the College Board. The rest of the authors have declared that they have no conflict of interest.

Received for publication November 20, 2007; revised May 14, 2008; accepted for publication May 15, 2008.

Available online June 24, 2008.

Reprint requests: Thomas P. Miller, MD, 360 East Beltline NE, Ste 100, Grand Rapids, MI 49506. E-mail: millerjt@aol.com, millert1@msu.edu.

0091-6749/\$34.00

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doi:10.1016/j.jaci.2008.05.021

Factors (ie, underlying constructs or latent variables) are not measured directly but instead are inferred from the variables that represent the factor. For example, a factor called *verbal ability* might contain variables such as spelling, reading comprehension, and analogies; this factor may be relatively distinct from a *mathematical ability* containing variables such as algebra, geometry, and trigonometry. Factor analysis is not only useful in a theoretical sense, given the scientific principle of parsimony, but also useful practically for narrowing the conversation down from a multitude of variables to a handful of critical factors. Factor analysis techniques have been used for many years in the development and evaluation of psychological measures²⁴ and are being increasingly applied to other areas of clinical medicine including asthma. Factor analysis techniques have been used to validate asthma-related survey instruments,^{25,26} determine whether a specific underlying construct or factor is associated with a specific asthma outcome,^{27,28} or determine the factor structure or common source of variance in a set of observed asthma-related variables.²⁹⁻³³ The current study applies factor analysis to a collection of medically relevant variables to explore the underlying factor structure of asthma symptoms, patient characteristics, and clinical management and care, as well as association with future morbidity in a population of children presenting to the ED with an asthma exacerbation. This is the first study that we are aware of that attempts to characterize a broad context of disease as is commonly observed clinically in the ED.

METHODS

Study population

The study population consists of a prospective cohort of 197 children (age 2-17 years) who presented to 1 of 3 EDs for the evaluation and treatment of an acute asthma exacerbation in western Michigan. The 3 hospitals were chosen to represent an urban, suburban, and rural location to ensure breadth of sampling. Children were eligible if they presented with signs and symptoms compatible with an acute asthma exacerbation (shortness of breath, coughing, wheezing, or chest tightness), and had a discharge diagnosis of asthma, had a previous diagnosis of asthma or reactive airways disease, or had filled a prescription for a bronchodilator in the past year. Patients were excluded if they had other significant illnesses or were hospitalized at the index visit. A convenience sample of children was enrolled in each ED by either trained research personnel at the urban and suburban sites or by respiratory therapists working at the rural hospital. To increase the external validity (generalizability) of the data collected, research staff worked a wide range of shifts (including weekends and evenings) to obtain a broadly representative case sample at each ED. The sample was found to be similar in age and sex distribution to all pediatric patients with asthma evaluated in the ED as tracked by billing records.³⁴ The Institutional Review Boards at the participating hospitals as well as the authors' home university approved the study protocol. Informed consent was obtained from the parent or guardian in the ED, and assent was obtained from all children age 7 years and older. A more detailed description of this study population has been published elsewhere.³⁴

Data collection

Data were obtained using 4 survey instruments. Information on the clinical presentation of the case, including presenting signs and symptoms, clinical evaluation, and treatments received, was abstracted from the ED medical record. Information including demographic information, asthma history, recent symptoms (over the period of the last 4 weeks, not including the current episode) and treatment, medical management including asthma care, and health care-seeking behaviors was obtained by a face-to-face interview conducted with the parent or guardian in the ED. Follow-up information was obtained at 2 weeks and 6 months after the index visit by telephone interview

with the parent or guardian. Follow-up information included details of the asthma care since the index visit, including usual and urgent medical care, medication use, and current symptoms. The parent or guardian was asked whether urgent medical treatment had been required since the index visit, where this care was obtained (ie, office visit, ED, or urgent care center), and whether the child was admitted to the hospital overnight. These questions were the basis for determining 6-month morbidity, which was assessed as an ordinal 3-level outcome: (1) no urgent care visits, (2) 1 or more asthma-related urgent care visits that did not result in an ED visit or hospitalization, or (3) 1 or more asthma-related ED visits or hospitalizations during the 6-month follow-up. Data were collected on clinical asthma features including recent symptoms, current and previous management, social factors, previous morbidity, and other factors reflecting standard clinical care. These variables were chosen because they had been used in consensus guidelines¹⁶ or in previous research^{35,36} and were felt to be components of common clinical practice. A total of 18 variables reflected this information. All variables were characterized according to what would be considered higher risk or lower risk for future morbidity. Most variables included in the analysis were dichotomous; where necessary, variables with multiple categories were dichotomized by using clinically relevant cut-points based on guidelines or literature.

Statistical methods

Exploratory factor analysis was undertaken by using SAS PROC FACTOR (SAS Institute Inc, Cary, NC), as described in standard textbooks.²² The set of variables was analyzed by the principal axis factor analysis method. The number of factors to retain was determined by a combination of parameters including the scree test (looking for a break or elbow in the scree plot), proportion of variation >10%, and interpretability criteria.²² Retained factors underwent promax (oblique) rotation, which (1) allows factors to correlate when the data indicate they are in fact correlated (vs constraining factors to be orthogonal as other procedures require) and (2) allows factor loadings to achieve a parsimonious and interpretable pattern (ie, attempt to have each variable load highest on only 1 factor and low on the other factors while still achieving good model fit). The rotated factor pattern matrix was used to determine the specific loadings of all variables on various factors. To assess interfactor correlations and correlation with 6-month morbidity, SAS-generated estimated factor scores were used and Pearson correlation coefficients calculated. Variables were coded to reflect the underlying concept. Therefore, an increased value for *current symptom severity* means increased current symptoms; an increased value for *previous severe disease* means increased previous ED visits, hospitalizations and so forth; a high value for *quality of care indicators* means a higher quality of care; and an increased value for *sociodemographic factors* means increased risk because of sociodemographic risk factors.

RESULTS

A total of 197 subjects were enrolled over a 1-year period, and follow-up information was available for 166 (84%). Five subjects were excluded from the factor analysis because of missing data, leaving 161 subjects for factor correlations. Demographic information of the subjects is displayed in Table I. The majority of the subjects was seen at the urban hospital and was more likely to be white and male. The specific observed variables, including risk definitions and distribution, are displayed in Table II. Six-month follow-up revealed that 23 (13.9%) subjects required an urgent care visit for asthma, 7 (4.2%) required an ED visit, and 6 (3.6%) were hospitalized for asthma since their index ED visit.

Factor analysis

The scree test, percent variability >10%, and interpretability criteria²² suggested 4 factors accounted for the largest portion of reliable variance and should be retained (the scree plot, Fig E1, is

TABLE I. Demographic characteristics

Variable	No. (%)
Age (y)	8.1 ± 4.3 (mean ± SD) (range, 2-17)
Hospital location	Urban 115 (69.3)
	Suburban 30 (18.1)
	Rural 21 (12.7)
Sex	Female 64 (38.6)
	Male 102 (61.5)
Race*	White 119 (71.7)
	Black 50 (30.1)
	Hispanic 26 (15.7)
	American Indian or Alaska native 7 (4.2)
	Asian 2 (1.2)
	Other 2 (1.2)
Parental education level†	Less than high school 23 (13.9)
	High school or GED 52 (31.3)
	1-3 Years of college 55 (33.1)
	4 Years of college or more 35 (21.1)

GED, General Educational Development.

*The survey instructions were to select 1 or more; therefore, n >166.

†Missing data for 1 individual; therefore, n = 165.

available in the Online Repository at www.jacionline.org). Analyses using 3-factor and 5-factor solutions were evaluated and found to be inferior to the 4-factor model. On the basis of the pattern of factor loadings for the observed variables, the identified factors or constructs were labeled *current symptom severity* (CSS), *quality of care* (QOC), *previous severe disease* (PSD), and *sociodemographic factors* (SDF). The observed variables that loaded highest on CSS included the frequency (in the last 4 weeks, excluding the current episode) of daytime symptoms, nocturnal symptoms, activity limitation, and having a severe flare adequate to limit speech. The variables that loaded highest on QOC included using an inhaled steroid, having seen an asthma specialist in the last 12 months, and having received a peak flow meter, a written asthma action plan, or asthma education. The variables that loaded highest on PSD included receiving oral or injectable steroids ever, and previous ED visit or hospitalization for asthma ever. The variables that loaded highest on SDF included the usual source for urgent care being an ED or medical center instead of a physician's office or clinic (during normal business hours), not having a primary care physician, Hispanic or black race, lower parental education level, being unable to fill prescriptions, or not having a follow-up appointment scheduled after the index ED visit.

Factor loadings for all variables are displayed in Table III. Most observed variables loaded most strongly on only 1 factor (displayed in *boldface* in Table III). Two observed variables, having a primary care provider and being able to fill prescriptions, did not load highly on any factor (although they did load highest on SDF). These variables, however, were included in the analysis because they are used commonly for risk assessment by clinicians and are recommended by guidelines.

Interfactor correlations

Evaluation of interfactor correlations revealed statistically significant positive correlations between CSS and QOC (.35;

$P < .0001$), between PSD and QOC (.34; $P < .0001$), and between CSS and PSD (.16; $P = .047$), showing that higher current symptoms were associated with both higher quality of care and previous severe disease. Increased previous severe disease was also associated with increased quality of care. Higher SDF was inversely associated with QOC (−.38; $P < .0001$) and CSS (−.21; $P = .008$), indicating that higher-risk sociodemographic factors were associated with both lower quality of care and lower current symptoms. PSD was the only factor significantly associated with 6-month morbidity (SMM; .17; $P = .027$). There was a trend toward a direct association between PSD and SDF (.15; $P = .058$). The correlation matrix between these factors and with SMM is displayed in Table IV.

DISCUSSION

The current study identified 4 factors that explain most of the variance observed in common clinical variables in the management and follow-up of a cohort of children with asthma. The current factor analysis differs from risk stratification tools or risk assessment models in that we are attempting to identify the latent variables (underlying constructs) that are reflected by commonly used observed variables, describe how these factors interrelate, and observe their association with morbidity as opposed to developing a clinical classification system to be applied to individual patients. In the current study, QOC was positively correlated with CSS and PSD and negatively associated with SDF. This would suggest that patients who may be at increased risk because of current symptom severity or previous severe disease are being identified by their physicians, and their quality of care is being increased accordingly. The negative correlation between QOC and SDF suggests that patients who are at increased risk for asthma morbidity because of sociodemographic factors are not being identified, or if identified, are not experiencing an increase in their quality of care. PSD was associated with increased CSS, which is not surprising because one would expect that individuals who experienced increased previous morbidity might have more severe symptoms. It is interesting, however, that there was a positive correlation between PSD and SDF (+.15), yet SDF was inversely related to CSS. This suggests that sociodemographic factors—as reflected in what our sociodemographic measures have in common—play a role in increasing risk of ED visits, yet are not reflected by increased symptom severity. The inverse relationship between CSS and SDF reveals that those with increased sociodemographic risk factors had fewer symptoms in the preceding 4 weeks (lower CSS). The only factor significantly associated with future morbidity (SMM) was the presence of previous severe disease (PSD), which is very consistent with previous literature.^{6,11-13,37-39}

These factors (CSS, QOC, PSD, and SDF) are consistent with the current asthma literature. There is a large body of literature that has identified individual factors that are associated with an increased risk for asthma morbidity.³⁻¹⁵ These risk factors seem to fall into similar categories as the factors empirically identified in this study. The literature supporting the association between increased symptom severity or decreased disease control and increased risk for future asthma morbidity is well established^{3,37} and includes factors such as increased symptom severity, increased frequency,^{3,37} decreased FEV₁,^{5,6} or increased β -agonist use.^{38,39} These variables are similar to the variables in our study that loaded on the factor CSS, including recent daytime and

TABLE II. Observed variables at baseline (definition and distribution)

Clinical variable	Low risk (%)	High risk (%)
Frequency of daytime symptoms*	≤2×/wk (74.1)	≥3×/wk (25.9)
Frequency of nocturnal symptoms*	≤2×/4 wk (74.1)	≥3×/4 wk (25.9)
Frequency of activity limitation*	≤2×/Last 4 wk (75.9)	≥3×/Last 4 wk (24.1)
Severe flare adequate to limit speech*	No (82.5)	Yes (17.5)
Using an inhaled steroid	Yes (52.4)	No (47.6)
Seen an asthma specialist (in last 12 mo)	Yes (27.7)	No (72.3)
Have a peak flow meter	Yes (43.4)	No (56.6)
Have a written action plan	Yes (45.8)	No (54.2)
Received asthma education (ever)	Yes (71.1)	No (28.9)
Been given oral or injectable steroids (ever)	No (22.3)	Yes (77.7)
Previous ED visit for asthma (ever)	No (16.3)	Yes (83.7)
Hospitalized for asthma (ever)	No (48.8)	Yes (51.2)
Usual source of urgent care (during normal business hours)	Primary physician if available (69.3)	ED or medical center (30.7)
Does your child have a primary care provider?	Yes (95.8)	No (4.2)
What race is your child?	White or Asian (53.6)	Black, Hispanic, or Native American, (46.4)
Parental education level	Any college or more (54.5)	High school graduate or less (45.5)
Are you usually able to fill your prescriptions?	Yes (92.8)	No (7.2)
By the 2-week follow-up, has your child had or arranged a follow-up appointment?†	Yes (50.0)	No (50.0)

*The symptom variables reflect symptoms during the 4 weeks before the index visit excluding the current episode.

†All baseline variables were determined at the index visit (except follow-up appointment).

TABLE III. Factor loadings of clinical variables (rotated factor pattern: standardized regression coefficients)

Clinical variable	Factor loadings			
	Factor 1 (CSS)	Factor 2 (QOC)	Factor 3 (PSD)	Factor 4 (SDF)
Frequency of daytime symptoms*	.71	-.10	.04	-.09
Frequency of nocturnal symptoms*	.63	-.09	.05	-.10
Frequency of activity limitation*	.71	.18	-.10	.09
Severe flare adequate to limit speech*	.63	.04	-.01	.10
Using an inhaled steroid	.17	.42	.18	-.19
Seen an asthma specialist (in last 12 mo)	.10	.50	-.14	.03
Have a peak flow meter	.11	.49	.09	.12
Have a written action plan	-.08	.66	.04	.18
Received asthma education (ever)	-.13	.54	.17	-.01
Been given oral or injectable steroids (ever)	-.02	.30	.40	-.16
Previous ED visit for asthma (ever)	-.05	.01	.66	.03
Hospitalized for asthma (ever)	.04	.11	.53	-.05
Usual source of urgent care (during normal business hours)	.08	-.34	.32	.36
Does your child have a primary care provider?	.01	-.22	.01	.28
What race is your child?	.06	.07	.20	.42
Parental education level	-.13	-.05	.05	.38
Are you usually able to fill your prescriptions?	.0	.11	-.07	.18
By the 2 week follow-up has your child had or arranged a follow-up appointment?†	-.01	.11	-.17	.43

The highest factor loading for each variable is displayed in boldface.

*The symptom variables reflect symptoms during the 4 weeks before the index visit excluding the current episode.

†All baseline variables were determined at the index visit (except follow-up appointment).

nocturnal symptoms, activity limitation, and a recent flare. The literature supporting the association between poorer quality of care and increased asthma morbidity includes not having an asthma action plan,^{6,39} not using a controller such as cromolyn^{7,8,38} or an inhaled steroid,^{7,9,10} low inhaled corticosteroid to β-agonist ratio,⁴⁰ or having a large number of prescribers.³⁸ These are similar to the variables in the current study (no inhaled corticosteroid, peak flow meter, action plan, asthma education, or specialist) that loaded on the factor QOC. Previous health care use for asthma has been one of the most consistent risk factors for

future morbidity. This includes previous ED visits,^{11,12,37-39} previous hospitalizations,^{6,13,38} and recent outpatient asthma visits,^{4,37,41} including unscheduled asthma visits.³⁷ Variables from our study that loaded on the factor PSD included previous ED visits (ever) and previous hospitalization for asthma (ever), as well as the previous need for oral or injectable steroids, which likely reflected a more severe asthma flare. These variables are likely valid measures of the underlying construct of previous severe disease because they are very similar to risk factors established in the literature.

TABLE IV. Factor correlation matrix

Factors	1, CSS	2, QOC	3, PSD	4, SDF	SMM
1, CSS	1.00				
2, QOC	.35 (<.0001)	1.00			
3, PSD	.16 (.047)	.34 (<.0001)	1.00		
4, SDF	-.21 (.008)	-.38 (<.0001)	.15 (.058)	1.00	
SMM	.01 (.914)	.13 (.10)	.17 (.027)	.05 (.56)	1.00

Pearson correlation coefficients are displayed with *P* values in parentheses.

The factor labeled SDF contained the following variables: the usual source for urgent care (using a medical center or ED during normal business hours for urgent care vs a physician's office or clinic), not having a primary care physician, black or Hispanic race, lower parental education level, not being able to fill prescriptions, or not having a follow-up appointment arranged after the index ED visit. This factor is therefore more heterogeneous in nature and thus difficult to define. Previous literature has demonstrated an association between demographic factors such as sex^{14,42} and ethnicity,^{43,44} and increased asthma morbidity. Socioeconomic factors such as income or poverty status,⁴⁵ educational level,⁴⁶ not having a personal physician,³⁸ or insurance status¹³ have been shown to be associated with asthma morbidity. Behavioral factors associated with increased asthma morbidity include smoking,¹⁵ illicit drug use,⁴⁷ psychiatric factors,^{9,48} lack of social support,⁴ crowding,⁴⁵ or language barriers.⁴⁹ Compared with socioeconomic or demographic factors, there is more variability in how psychosocial variables are defined and measured.^{46,50-55} It is likely that socioeconomic, demographic and psychosocial factors are much more complex and influential than is reflected in any 1 data set, including the one used in this investigation. This is supported by the fact that the convergent validity of the variables that loaded most strongly on sociodemographic factors was poor. Convergent validity is 1 component of construct validity. It reflects the degree to which variables thought to reflect the same underlying construct are correlated with each other. The convergent validity of the other factors (eg, CSS, QOC, PSD) was good (correlation matrices for all factors, [Tables E1-E4](#), is available in the Online Repository at www.jacionline.org).

Various risk assessment models, incorporating the current morbidity risk literature, have been proposed.^{5,11,20,33,38,41,50,56-60} A common feature of these risk assessment models is their inability to predict which patients are at risk of subsequent asthma utilization (ie, low predictive value). This may be because these models incorporate very few socioeconomic or psychosocial variables. In the current study, PSD was the only factor associated with SMM. This may be helpful in identifying an individual at increased risk; however, it does not indicate why they are at increased risk in the first place. The fact that none of the other identified constructs were associated with SMM is consistent with the low positive predictive values noted in risk models based on the current morbidity risk literature. This is not surprising because the current study used common clinical variables reflected in the current literature. Two conclusions may be drawn from this. The lack of association between the constructs identified and SMM may reflect low sensitivity of the specific variables to reflect the underlying constructs accurately (low construct validity), or perhaps more likely, it may reflect the role of other, as of yet unidentified constructs or factors that influenced SMM. To identify these factors that are currently underappreciated, it may be

beneficial to consider current disease control and prevention of morbidity as separate goals. It is possible that if we consider good current disease control as adequate to prevent future morbidity, we will miss factors that are associated with morbidity yet not prevented by good quality chronic care. This is observed clinically in the individuals who have mild chronic disease, yet are at risk for severe exacerbations.

Previous authors, convinced that reductionism alone will not lead to a complete understanding of living organisms,⁶¹ have urged the acceptance of the principles of systems biology in the basic sciences. Applying some of the concepts of systems biology to clinical research is also advisable. Most clinical risk models tend to be reductionistic in philosophy, which can be very beneficial if we wish to identify a few easily determined risk factors that, if modified, can alter future risk. With this type of approach, however, we will never truly be able to develop causal models that explain the complex interplay between genetic predisposition, environmental exposures, host responses, disease development, and disease progression. Only when we incorporate the entire context of disease that defines this complex *clinical system* (into what could be described as a *clinical systems* approach) will we be able to extend the revolution occurring in the basic sciences to a fully integrated model from genome and proteome to clinical interactions and outcomes. The methodology used in the current study can be thought of as expansive, in that it is an attempt to incorporate a broader context of disease, yet reductionistic in the sense that the observed variables were grouped into factors that likely represent underlying constructs. The fact that the variables used in the current study were confined to those that are commonly used clinically limited the ultimate predictive accuracy of the model; however, because these variables have a basis in the literature, we felt that this was a good place to start.

In summary, we have identified 4 factors that underlie current asthma care. We have observed that quality of care was better in subjects with increased current symptoms or previous severe disease, but was poorer in individuals with adverse sociodemographic factors. Current assessment and treatment methods do not adequately account for all the underlying factors (ie, the entire context of disease) likely operative in asthma morbidity, because previous severe disease was the only factor associated with SMM. We have, however, demonstrated a methodology that we believe could be used to describe the disease experience more accurately.

Several specific areas of future research are clear from these findings. Besides validation of the identified constructs, clarification of the construct of sociodemographic factors, with emphasis on factors that affect adherence and health care utilization, would be a good first step. Identifying additional but to date unrecognized contributors to morbidity that may or may not influence chronic control is also advisable. This could involve biomarkers or variables reflecting intrinsic pulmonary response to triggers or responsiveness to steroids. Starting with these areas ideally will allow us to identify more effectively the specific areas of risk that individuals may exhibit, thus allowing targeted intervention to decrease the burden of asthma morbidity and mortality both on individuals and societies. Increasing our attention to social issues that our patients are facing, and partnering with them more effectively to increase their quality of care, is a clear clinical application of the findings of this study. Efforts to define effective interventions, beyond the current quality of care measures, to reduce morbidity in those individuals with previous severe episodes are also needed. From a

methodologic standpoint, identifying latent variables using observed variables beyond those in common current use will likely facilitate the development of models that more accurately encompass the entire context of disease and thus are better predictors of future morbidity.

Clinical implications: Increased efforts are needed to improve the quality of care for individuals with adverse sociodemographic factors and define effective interventions to reduce morbidity in individuals with previous severe episodes of asthma.

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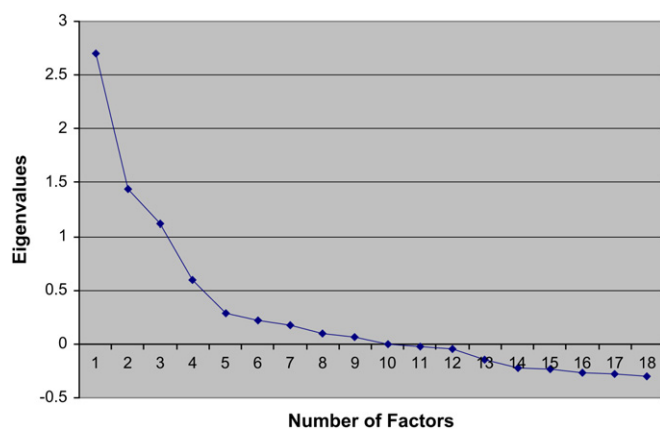


FIG E1. Scree plot. The scree plot is a representation of the eigenvalues of all factors extracted. The number of factors to retain can be estimated (scree test) by the factors to the left of the break or “*elbow*” noted in the graph.

TABLE E1. CSS factor correlation matrix

Clinical variable	Frequency of daytime symptoms	Frequency of nocturnal symptoms	Frequency of activity limitation	Severe flare in last 4 wk (limit speech)
Frequency of daytime symptoms	1.00			
Frequency of nocturnal symptoms	.50 (<.0001)	1.00		
Frequency of activity limitation	.54 (<.0001)	.41 (<.0001)	1.00	
Severe flare in last 4 wk (limit speech)	.42 (<.0001)	.34 (<.0001)	.52 (<.0001)	1.00

Pearson correlation coefficients are displayed (with *P* values in parentheses).

TABLE E2. QOC factor correlation matrix

Clinical variable	Inhaled steroid	Asthma specialist	Have a peak flow meter	Written action plan	Asthma education
Using an inhaled steroid	1.00				
Asthma specialist (last 12 mo)	.30 (<.0001)	1.00			
Have a peak flow meter	.22 (<.005)	.24 (<.005)	1.00		
Have a written action plan	.33 (<.0001)	.31 (<.0001)	.37 (<.0001)	1.00	
Asthma education (ever)	.26 (<.001)	.19 (<.05)	.26 (<.001)	.42 (<.0001)	1.00

Pearson correlation coefficients are displayed (with *P* values in parentheses).

TABLE E3. PSD factor correlation matrix

Clinical variable	Oral or injectable steroids ever	Previous ED visit ever	Hospitalized ever
Oral or injectable steroids ever	1.00		
Previous ED visit (ever)	.36 (<.0001)	1.00	
Hospitalized for asthma (ever)	.31 (<.0001)	.39 (<.0001)	1.00

Pearson correlation coefficients are displayed (with *P* values in parentheses).

TABLE E4. SDF correlation matrix

Clinical variable	Usual source of urgent care	Primary care provider	Race	Parental education level	Able to fill prescriptions	Made follow-up appointment
Usual source of urgent care	1.00					
Primary care provider	.25 (<.005)	1.00				
Race	.27 (<.001)	.11 (NS)	1.00			
Parental education level	.15 (<.05)	.17 (<.05)	.17 (<.05)	1.00		
Able to fill prescriptions	-.08 (NS)	.06 (NS)	.11 (NS)	.12 (NS)	1.00	
Made follow up appointment	.17 (<.05)	.09 (NS)	.11 (NS)	.14 (NS)	.09 (NS)	1.00

Pearson correlation coefficients are displayed (with *P* values in parentheses).