Ethnic Differences in Perception of Lung Function

A Factor in Pediatric Asthma Disparities?

Gregory K. Fritz¹, Elizabeth L. McQuaid¹, Sheryl J. Kopel¹, Ronald Seifer¹, Robert B. Klein², Daphne Koinis Mitchell¹, Cynthia A. Esteban², Jose Rodriguez-Santana³, Angel Colon³, Maria Alvarez³, and Glorisa Canino³

¹Bradley Hasbro Research Center and ²Department of Pediatrics, Warren Alpert Medical School of Brown University, Providence, Rhode Island; and ³University of Puerto Rico, San Juan, Puerto Rico

Rationale: Disparities in pediatric asthma exist in that Latino children have higher prevalence and greater morbidity from asthma than non-Latino white children. The factors behind these disparities are poorly understood, but ethnic-related variations in children's ability to accurately recognize and report their pulmonary functioning may be a contributing process.

Objectives: To determine (1) if differences exist between Latino and non-Latino white children's perceptual accuracy and (2) whether these differences are related to asthma outcomes.

Methods: Five hundred and twelve children, aged 7–16 years (290 island Puerto Ricans, 115 Rhode Island Latinos, and 107 Rhode Island non-Latino white children) participated in a 5-week home-based protocol in which twice daily they entered subjective estimates of their peak expiratory flow rate into a hand-held, programmable spirometer and then performed spirometry. Their accuracy was summarized as three perceptual accuracy scores. Demographic data, asthma severity, intelligence, emotional expression, and general symptom-reporting tendencies were assessed and covaried in analyses of the relationship of perceptual accuracy to asthma morbidity and health care use.

Measurements and Main Results: Younger age, female sex, lower intelligence, and poverty were associated with lower pulmonary function perception scores. Island Puerto Rican children had the lowest accuracy and highest magnification scores, followed by Rhode Island Latinos; both differed significantly from non-Latino white children. Perceptual accuracy scores were associated with most indices of asthma morbidity.

Conclusions: Controlling for other predictive variables, ethnicity was related to pulmonary function perception ability, as Latino children were less accurate than non-Latino white children. This difference in perceptual ability may contribute to recognized asthma disparities.

Keywords: childhood asthma; symptom recognition; disparities

Disparities in pediatric asthma prevalence and morbidity exist, based on ethnic and cultural differences, such that higher rates of asthma have been documented in African American and Latino children compared with non-Latino white children (1, 2). Puerto Rican children, both from the island of Puerto Rico and the U.S. mainland, have the highest prevalence and mortality from asthma of any ethnic group (3–6). Although the magnitude and significance of asthma disparities are widely

AT A GLANCE COMMENTARY

Scientific Knowledge on the Subject

Latino children have greater asthma prevalence and morbidity than non-Latino white children. The mechanism behind these asthma disparities is not clearly understood, but ethnic differences in accuracy of pulmonary function perception may be a contributing factor.

What This Study Adds to the Field

Latino children with asthma are less accurate at subjectively assessing their lung function status than non-Latino white children, tending to overestimate their degree of compromise. Better perceptual accuracy is modestly associated with less morbidity and lower health care use.

recognized, the mechanisms behind them are poorly understood. The multifactorial etiology of asthma and the complexities of asthma management suggest that many processes contribute to the ultimate disparities in asthma outcomes. Variations in the ability of children with asthma to accurately recognize and report their pulmonary function, referred to as perceptual accuracy, may be one such process.

Since Rubenfeld and Pain (7) demonstrated that 15% of adults with asthma were unable to sense even marked airway obstruction during methacholine challenge, there has been a growing recognition that underperception of compromised lung function is a factor influencing asthma morbidity and mortality in patients of all ages (8–10). Conversely, overperception of pulmonary compromise when function is normal or near normal has been associated with iatrogenic problems, overuse of medications, and excessive health services use (11, 12). More recent research has suggested that psychological factors can influence the perception of dyspnea (13–15). However, ethnic or cultural differences in asthma perception have not been evaluated.

The rationale for exploring perceptual accuracy as a possible mechanism contributing to asthma disparities is based on evidence linking cultural differences to the perception of pain, other physical symptoms, and emotional distress—distinct but related psychological processes. Cultural factors are among the mediating variables in pain perception and important predictors of reported pain intensity (16, 17). Studies of the tendency to recognize and report physical symptoms other than pain have shown that Latino adults, and Puerto Ricans in particular, report more physical symptoms than do non-Latino white subjects (18, 19). Comparable data dealing with ethnic differences in the tendency of children to report physical symptoms are lacking. Several studies have documented ethnic differences in children's recognition and reporting of negative emotional symptoms, another type of awareness of internal states (13, 20).

(Received in original form June 3, 2009; accepted in final form March 12, 2010)

Supported by U01-H1072438 (G. Canino and G. Fritz, principal investigators) from the National Heart, Lung, and Blood Institute.

Correspondence and requests for reprints should be addressed to Gregory K. Fritz, M.D., Bradley Hasbro Research Center, Coro West (Suite 204), 1 Hoppin Street, Providence, RI 02903. E-mail: Gfritz@lifespan.org

This article has an online supplement, which is accessible from this issue's table of contents at www.atsjournals.org

Am J Respir Crit Care Med Vol 182, pp 12–18, 2010

Originally Published in Press as DOI: 10.1164/rccm.200906-0836OC on March 18, 2010
Internet address: www.atsjournals.org

The Rhode Island/Puerto Rico Asthma Center (RIPRAC) was established as one of four National Heart, Lung, and Blood Institute (Bethesda, MD) Collaborative Centers to explore asthma disparities. One particular area of interest for the RIPRAC is cultural factors in asthma perceptual accuracy, and by design we sought to test the following hypotheses: (1) differences exist between Latino and non-Latino white children's pulmonary function perception ability and (2) more accurate perception ability is associated with less asthma morbidity and use of services.

METHODS

The conceptual model and the study methods have been described in detail elsewhere (21, 22). Institutional review boards at Rhode Island Hospital (Providence, RI) and the University of Puerto Rico (San Juan, Puerto Rico) approved the study.

Subjects participated in four RIPRAC components over approximately 4 months. An initial diagnostic session with an asthma specialist included an asthma symptom history, review of medication regimen, physical examination, pulmonary function testing, and allergy testing. At a subsequent session, subjects were thoroughly trained in the use of the AM2 programmable, hand-held spirometer (VIASYS Healthcare Inc., Yorba Linda, CA). The procedure for training child participants, quantifying subjective estimates, and obtaining daily spirometric data in a naturalistic setting has been developed, refined, and reported over a number of years in several distinct groups of children (15, 23–25). Although the AM2 device provides a number of spirometric variables (including FEV₁ and FEV_{25–75}), the peak expiratory flow rate (PEFR) was chosen as the objective pulmonary function index for the perception task despite its effort-dependent characteristics because many children had previous experience with peak flow meters; those who did not received extra training. Subjects were asked to “guess” their PEFR as a subjective estimate of their pulmonary function at that moment. When that estimate was “locked in,” the device allowed the subject to proceed with spirometric assessment, and the best of three blows was stored with the corresponding subjective data.

Institutional review board requirements precluded blinding the children to the spirometric results, thereby raising the possibility of a learning effect over the course of the study. In a prior study, analyses of perceptual accuracy in the first half of the study period compared with the last half revealed no significant difference (25). These analyses were also repeated with the current data. In comparing each subject's first 10 observations with their last 10, the average percentage in the accurate zone was 58.2 versus 58.8%. There was also no significant change in the perception indices when these analyses were limited to compromised observations, suggesting that spontaneous learning does not occur during the protocol. Subjects were instructed to perform the

AM2 procedure twice daily at home before taking any asthma medications for 5 weeks. Study staff contacted participants regularly during the assessment period to encourage protocol adherence and to ensure device integrity. This protocol resulted in an average of 49.7 subjective/objective data points for each child included in the study. Data for each subject were downloaded in the laboratory and summarized, using the Asthma Risk Grid (26) described below.

Measures

Poverty threshold: Each family was classified as falling above/below the poverty line by comparing their annual household income with federal standards for a family of their size (27).

Asthma severity: Study clinicians rated asthma severity on the basis of international guidelines (28), using reported symptom frequency, prescribed asthma medications, and pulmonary function test results.

Asthma morbidity: Asthma morbidity, a complex construct, was quantified as two variables. Asthma functional morbidity was assessed retrospectively with the Rosier Asthma Functional Severity Scale, which summarized the frequency of episodes, the frequency of symptoms between episodes, and the intensity of impairment during and between episodes over the past year (29). Validity and internal consistency of the measure have been established (29) and the scale has been translated and adapted for use with Latino groups (30).

Asthma health care use: Asthma health care use was quantified with three single items assessing parent-reported frequency of hospitalizations, emergency department (ED) visits, and unscheduled medical visits due to the child's asthma in the previous 12 months. The absolute number of hospitalizations and visits was used in data analyses.

Pulmonary function perception: Asthma Risk Grid: For each child, every subjective PEFR guess and corresponding actual PEFR recorded by the AM2 over the assessment period (both converted to percentage of personal best) was plotted on the Asthma Risk Grid (Figure 1). Each point in a given child's perceptual accuracy data set falls into the accurate zone (subjective assessment close to objective clinical status), the danger zone (subject misses clinically significant functional compromise), or the magnification zone (oversensitivity to minimal compromise). Although a few subjects were almost “pure culture” examples of over- or under-perceivers, all had at least some points falling in each of the zones. Rather than categorizing an individual child as an accurate, over-, or under-perceiver, the scores were treated as continuous variables for each child. Thus, each child's pattern of perceptual accuracy is summarized as the percentage of total points falling in each of the three zones. Figure 1 shows a plot of actual PEFR versus guessed PEFR for a child with a high percentage of blows in the accurate zone.

Previous studies have identified a number of factors predictive of perceptual ability (25, 31–33), which were assessed with the following instruments administered to the children by a bilingual research assistant in the language of their choice. All measures were translated from

Figure 1. Asthma Risk Grid, example 1: high proportion of blows in the accurate zone.

English to Spanish and back translated by a bilingual committee according to standard procedures (21).

Child Somatization Inventory (CSI): The CSI is a 35-item self-report measure of children's somatic complaints experienced during a 2-week period (34).

Emotion Expression Scale for Children (EESC): The EESC is a 16-item scale that assesses various approaches to emotion expression, particularly lack of emotional awareness and unwillingness to express emotions (35).

Kaufman Brief Intelligence Test, Second Edition (36): The Matrices section is a nonverbal, 48-item measure involving meaningful and abstract visual stimuli requiring nonverbal reasoning and flexibility.

Analysis Plan

Associations between grid scores and key study variables were assessed on the basis of the appropriate parametric and nonparametric statistics (Pearson's correlations for associations among measures, analyses of variance for group differences on continuous measures, chi-square tests for group differences on proportions). Variables significantly related to grid scores were controlled in analyses of covariance examining differences in perception scores by ethnic group, with Scheffé-type post hoc comparisons of group means adjusted for the covariates in the models. Relationships between grid scores and asthma outcomes were examined by ethnic group to assess differential patterns of association. Analyses were conducted with SPSS, version 12 (SPSS Inc., Chicago, IL).

The larger RIPRAC study, with a sample size of 967, was the basis for original power calculations at the outset. For the current report with a perceptual accuracy cohort of 512 (Figure 2), power remained high to detect modest effects—greater than 0.80 to detect correlations as small as 0.15 including 5 covariates. For the smallest subsample (the 107 Rhode Island non-Latino white [RI NLW] subjects), power was somewhat reduced, but remained greater than 0.80 to detect correlations as small as 0.28 with 5 covariates.

RESULTS

Sample Characteristics

Figure 2 summarizes participant screening, enrollment, and flow through the entire RIPRAC study. As described in a previous

publication (22), subjects were a convenience sample recruited from a variety of sources in San Juan, Puerto Rico and the metropolitan area of Providence, Rhode Island. Of the 787 subjects who began the perceptual accuracy component, 512 returned the AM2 device with a sufficient number of valid data points (minimum of 20; details of the data-cleaning process are available on request) to be included in subsequent analyses. The 275 subjects who were lost to follow-up or had insufficient data were compared with the 512 included in analyses to look for systematic biases (see Table E1 in the online supplement). No differences were found in relation to age, sex, poverty status, or asthma severity. Ethnic group membership was associated with completion status. Completion rates of RI non-Latino white subjects (71.8%) and island Puerto Ricans (72%) differed significantly from the completion rate of RI Latinos (48.7; $P < 0.01$). Data for this study were thus provided by 512 children aged 7–16 years and their primary caretakers, 98% of whom were mothers. Demographic and clinical characteristics of the children are summarized in Table 1. The sample was composed of 290 Island Puerto Rican children, 115 RI Latino children (51 Puerto Rican and 64 Dominicans), and 107 RI NLW children. No differences were found between RI Puerto Rican and Dominican subsamples in child age or sex, maternal education, poverty threshold, or asthma severity; therefore these participants were combined to form an RI Latino subgroup for this article. The island Puerto Rican group was significantly poorer than the Rhode Island Latino and NLW groups, whereas the NLW group had significantly more boys than the other two groups. At the time of assessment, the proportion of participants who reported they had been prescribed inhaled corticosteroids was lower in the island Puerto Rican group relative to the Rhode Island groups. Patterns of asthma severity differed significantly between the groups, as more island Puerto Rican children had mild intermittent asthma and fewer had severe persistent asthma compared with both of the Rhode Island groups. Asthma control of both the island Puerto Ricans and RI

Figure 2. Rhode Island/Puerto Rico Asthma Center (RIPRAC) participants in perceptual accuracy cohort.

TABLE 1. DEMOGRAPHIC AND CLINICAL CHARACTERISTICS OF STUDY SAMPLE

	Island PR	RI Latino	RI NLW	Group Differences
Participants	290	115	107	N/A
Age, mean (SD)	11.1 (2.6)	11.0 (2.4)	10.7 (2.6)	$F(2,511) = 1.2$
Sex, % male	52.6	47.6	66.4	$\chi^2 = 8.5^*$
% below poverty threshold	67	54	10	$\chi^2 = 101.8^\dagger$
PEF (% personal best); mean (SD)	76.4 (12.4)	80.4 (10.1)	82.3 (8.9)	$F(2,509) = 12.7^\dagger$ (PR < RI)
FEV ₁ (% personal best), mean (SD)	77.0 (12.3)	80.4 (11.5)	81.9 (10.8)	$F(2,509) = 8.4^\dagger$ (PR < RI)
Inhaled corticosteroid, %	14.5	37.4	49.5	$\chi^2 = 57.0^\dagger$
GINA asthma severity, %				$\chi^2 = 37.9^\dagger$
Mild intermittent	34.1	15.7	21.5	
Mild persistent	28.6	25.2	26.2	
Moderate persistent	28.3	28.7	30.8	
Severe persistent	9.0	30.4	21.5	
GINA asthma control, %				$\chi^2 = 7.7$
Controlled	25.3	14.3	24.3	
Partly controlled	42.8	46.4	48.6	
Uncontrolled	31.9	39.3	27.1	

Definition of abbreviations: GINA = Global Initiative for Asthma; N/A = not applicable; NLW = non-Latino white; PEF = peak expiratory flow; PR = Puerto Rico; RI = Rhode Island.

* $P < 0.05$.

† $P < 0.01$.

Latino groups was significantly worse than that of the Rhode Island non-Latino white subjects. (These findings relating to severity are presented in detail elsewhere [22]).

Correlates of Perceptual Accuracy in Asthma

Factors known from our own or others' previous research to be predictive of perceptual accuracy were analyzed in relation to the three zone scores of the Asthma Risk Grid; results are presented in Table 2. Older children were more accurate and less likely to have points in the danger zone. Girls had higher magnification scores, lower danger zone scores, and were overall less accurate than boys. Poverty was associated with lower accuracy and higher magnification scores. Greater intelligence was strongly associated with higher accurate zone and lower magnification scores. Asthma severity, expressed emotion, and treatment with inhaled corticosteroids were not predictive of any aspect of perceptual accuracy and were therefore excluded as covariates in subsequent analyses. Thus age and poverty were the covariates used in subsequent analyses.

The data were examined to determine whether perception differed according to participants' degree of lung function compromise throughout the study, which was classified on the basis of the relatively effort-independent FEV₁ (also available from the AM2), as uncompromised (FEV₁ greater than 80% of personal best) or compromised (FEV₁ less than or equal to 80% of personal best). Overall, 45% of the children had a mean FEV₁ in the compromised range, but this varied by group: 52% of island Puerto Rican children had a mean FEV₁ not exceeding 80% of personal best compared with 34% of RI NLWs and 36% of RI Latinos. The results of analyzing lung function data in relation to perceptual scores are summarized in Table 3. Level of lung function was unrelated to accuracy but was related to the type of inaccuracy, at least partly on a definitional basis (the danger zone entailed lung function below 80% by definition).

Perceptual Accuracy in Latino and Non-Latino White Children

Differences in the three perceptual accuracy scores were found between Latino and NLW children (Table 4). Island Puerto Rican children had the lowest accuracy scores and the highest magnification scores, followed by RI Latinos in both instances. Both Latino groups differed from NLW children (and from each other) in having this pattern of tending to overestimate respiratory compromise leading to lower accuracy in pulmonary

function perception. Given the relatively few points that fell in the danger zone for most children, and the large sample size, the small differences between the danger zone scores of the Latino groups are not likely to be clinically meaningful.

Perceptual Accuracy and Asthma Morbidity

For the 512 children in this study, perceptual accuracy scores were modestly correlated with most indices of morbidity, as summarized by the correlation coefficients in Table 5. Higher accuracy scores were associated with less functional morbidity, and with fewer hospitalizations, emergency room episodes, and unscheduled doctor visits. Higher magnification scores were associated with the utilization variables in the direction of increased health care use. Danger zone scores were not associated with asthma functional morbidity, and were unrelated to any of the utilization variables.

Follow-up analyses were conducted to examine the pattern of correlations between the three pulmonary function perception scores and the indices of asthma morbidity for each ethnic group. For RI Latinos, asthma functional morbidity was related to the accurate zone score ($r = -0.34$; $P < 0.01$) and the magnification zone score ($r = 0.23$; $P < 0.05$). There were no associations between health care use indices and zone scores. For island Puerto Ricans, there was only a weak relationship between the magnification zone score and hospitalizations

TABLE 2. CORRELATES OF SYMPTOM PERCEPTUAL ACCURACY

	Accurate Zone	Danger Zone	Magnification Zone
Age	0.17*	-0.25*	-0.04
Female sex	-0.14*	-0.10†	0.18*
Poverty threshold (higher score = poorer)	-0.19*	0.00	0.18*
Asthma severity	0.02	0.07	-0.05
Expressed emotion (EESC)	0.08	0.05	-0.05
Intelligence (KBIT)	0.26*	-0.06	-0.22*
Somatic symptom reporting (CSI)	-0.03	0.10†	0.03
Inhaled corticosteroid treatment	0.08	0.00	0.08

Definition of abbreviations: CSI = Child Somatization Inventory; EESC = Emotion Expression Scale for Children; KBIT = Kaufman Brief Intelligence Test.

As determined by Pearson r correlation.

* $P < 0.01$.

† $P < 0.05$.

TABLE 3. PERCEPTUAL ACCURACY IN UNCOMPROMISED VERSUS COMPROMISED PULMONARY FUNCTION

	Percentage of Points in Each Perception Zone		
	Percentage in Accurate Zone	Percentage in Danger Zone	Percentage in Magnification Zone
Uncompromised ($FEV_1 > 80\%$ personal best)	62	4	33
Compromised ($FEV_1 \leq 80\%$ personal best)	56	15	29

($r = 0.12$; $P < 0.05$), and for the NLW group only ED visits were related to accurate zone scores ($r = -0.20$; $P < 0.05$).

DISCUSSION

This study explored whether differences exist between Latino and non-Latino white children with asthma in their pulmonary function perception ability and how these differences relate to asthma morbidity. In a large and carefully evaluated sample we found that older age, male sex, less poverty, greater cognitive ability, and a tendency to report more general somatic symptoms were associated with better perceptual accuracy. Controlling for these covariates, non-Latino white children were more accurate perceivers than Latino children, whose inaccuracy was primarily in the direction of overperception of minimal actual compromise. Among the Latinos, those living in Rhode Island (Puerto Ricans and Dominicans) were more accurate than island Puerto Ricans. Use of inhaled corticosteroids was not found to be related to any aspect of pulmonary function perception in this sample, despite several reports to the contrary in small studies of adults with severe asthma (37, 38).

Motivated by an interest in understanding the factors behind the well-documented ethnic disparities in pediatric asthma, this study is the first to demonstrate clear differences in pulmonary function perceptual ability between Latino and NLW children with asthma. For the entire sample, accurate perception consistently predicted less functional morbidity and lower health care use. Analyses of significant relationships between perceptual accuracy scores and asthma outcomes by ethnic group did not yield a meaningful pattern of results, likely due to a combination of reduced power, a relatively large number of analyses, and the multiple factors associated with the different health care systems (22).

It is important to note in interpreting these results that the three perceptual accuracy scores are not independent; for each child the three scores add up to 100%. Thus, if a child is inaccurate in either the danger zone or the magnification zone, the percentage of points in the accurate zone will necessarily be lower. For the Latino children, their inaccuracy tended to be in the direction

of magnification: compared with their NLW counterparts, they more often subjectively reported that they felt more compromised than their objective lung function indicated. Because functional morbidity involves substantial subjectivity in the reporting and entails no professional involvement (unlike, e.g., hospitalization), functional morbidity might be expected to be more strongly related to high sensitivity to physical symptoms than health care use variables.

The fact that boys were overall more accurate than girls in perceiving their asthma symptoms is noteworthy, especially in light of research showing that airway hyperreactivity decreases after puberty in boys but not in girls (39). In our large, multiethnic sample, boys less than 11 years of age had, on average, 57% of their points in the accurate zone compared with 70% for boys more than 11 years of age. In contrast, the mean accurate zone score of 52% for younger girls was quite comparable to the 58% score for girls more than 11 years of age. The RIPRAC protocol did not systematically assess airway hyperresponsiveness, but these data suggest a possible inverse relationship between hyperresponsiveness and symptom perception ability.

The relationship between recognized asthma disparities and perceptual ability in the Latino population is likely bidirectional. In this study, the magnification scores of Latinos paralleled the reported rates of asthma morbidity and mortality (40): highest among island Puerto Ricans, next highest among Puerto Ricans and Dominicans living in Rhode Island, and substantially lower among NLWs. The personal familiarity of patients and families with individuals who had near-death or fatal asthma episodes—relatively common in Puerto Rico—would likely increase oversensitivity to even mild asthma symptoms, which could result in higher magnification scores.

Conditioning effects on perceptual accuracy are possible over time given the chronic nature of asthma, and patients are vulnerable to overperception of familiar symptoms (41). If there is differential access to asthma health care for Latinos compared with NLWs, similar to what has been documented in the administration of analgesics (42), Latinos would reasonably expect to have less access except when their compromise is severe. Magnification of minor degrees of compromise might thus be reinforced by anxious families who are worried that their child might otherwise not receive care they believe to be needed.

TABLE 4. ETHNIC GROUP DIFFERENCES IN PERCEPTUAL ABILITY*: PERCENTAGE OF POINTS IN EACH PERCEPTION ZONE

	Island PR	RI Latino	RI NLW	Group Difference
Percentage in accurate zone [†]	55 (28)	62 (28)	71 (22)	$F(2,508) = 12.31^{\dagger}$
Percentage in danger zone [§]	8 (13)	13 (17)	9 (13)	$F(2,508) = 4.15^{\parallel}$
Percentage in magnification zone [†]	37 (30)	26 (28)	19 (21)	$F(2,508) = 14.43^{\dagger}$

Definition of abbreviations: NLW = non-Latino white; PR = Puerto Rico; RI = Rhode Island.

Values represent means and SD.

* Adjusted for the following covariates: child age and poverty threshold.

[†] Each group is significantly different from the other two groups.

[§] $P < 0.01$.

[§] The island PR group is different from the RI Latino group.

^{||} $P < 0.05$.

TABLE 5. PERCEPTUAL ACCURACY AND ASTHMA MORBIDITY IN CHILDREN

	Accurate Zone	Danger Zone	Magnification Zone
Asthma functional morbidity	-0.12*	0.06	0.08
Hospitalizations	-0.13*	0.04	0.14*
ED visits	-0.13*	0.03	0.11 [†]
Unscheduled doctor visits	-0.12*	0.02	0.10 [†]

Definition of abbreviation: ED = emergency department.

$n = 512$ children; Pearson r values are shown.

* $P < 0.01$.

[†] $P < 0.05$.

Conversely, to the degree that greater symptom magnification by Latinos leads to higher ED use, unscheduled office visits, hospitalizations, and illness behavior, the tendency toward magnification could be viewed as a cause of asthma disparities rather than a result.

Several limitations of this study should be noted. The relationships between perceptual accuracy, ethnicity, and asthma morbidity were statistically significant—sometimes highly so—but the relationships were modest. This pattern is common in behavioral research, in which the typical effect size accounts for approximately 9% of variance. Despite having the majority of variance unexplained, understanding a small component of a complex behavioral phenomenon can help unravel some of the explanatory pathways. Interpretation must take place in the context of other important factors at the biological, environmental, individual and family, cultural, and health care system levels that impact both perceptual ability and asthma morbidity (14). The subjects, although thoroughly evaluated and large in number, came from a convenience sample in both Rhode Island and Puerto Rico, with some biases noted between those who were included in the analyses and those who were excluded, and thus these results cannot be extrapolated to the population as a whole. The Latinos in this sample were intentionally limited to Caribbean groups (Dominicans and Puerto Ricans), and findings may not apply to other Latinos, such as Mexicans, who have different patterns of asthma prevalence and presentation (40).

Conflict of Interest Statement: G.K.F. received \$10,001–\$50,000 from John Wiley & Sons in consultancy fees as an Editor, Brown University Child & Adolescent Behavior Ltr. E.L.M. does not have a financial relationship with a commercial entity that has an interest in the subject of this manuscript. S.J.K. is employed by the NIH, whose position as project director is funded by NIH grants. R.S. does not have a financial relationship with a commercial entity that has an interest in the subject of this manuscript. R.B.K. does not have a financial relationship with a commercial entity that has an interest in the subject of this manuscript. D.K.M. does not have a financial relationship with a commercial entity that has an interest in the subject of this manuscript. C.A.E. does not have a financial relationship with a commercial entity that has an interest in the subject of this manuscript. J.R.-S. received \$1,001–\$5,000 from GlaxoSmithKline, \$1,001–\$5,000 from Schering Plough, and \$1,001–\$5,000 from Merck in promotional lecture fees, \$10,001–\$50,000 in sponsored grants for a collaborative study from Novartis and \$50,001–\$100,000 in sponsored grants for a collaborative dengue vaccine study from GlaxoSmithKline. A.C. received up to \$1,000 from Schering, up to \$1,000 from GlaxoSmithKline, up to \$1,000 from Merck, and up to \$1,000 from Auxilio Moto in lecture fees and \$1,001–\$5,000 for serving as an expert witness for a premier attorney at law (esquire). M.A. received \$6,000–\$7,000 from Merck, Sharpe, and Dohme in lecture fees. G.C. does not have a financial relationship with a commercial entity that has an interest in the subject of this manuscript.

Acknowledgment: The authors thank the families that participated in the RIPRAC study in Puerto Rico and Rhode Island, and the research assistants at both sites who worked diligently to collect the data. The authors also gratefully acknowledge data management assistance from Pedro Garcia, B.A., Vilmary Cruz Perez, B.S., Brenda Martinez Nieves, Ph.D., and Marcia Selinger, M.A.

References

- Homa DM, Mannino DM, Lara M. Asthma mortality in US Hispanics of Mexican, Puerto Rican, and Cuban heritage, 1990–1995. *Am J Respir Crit Care Med* 2000;161:504–509.
- Beckett WS, Belanger K, Gent JF, Holford TR, Leaderer BP. Asthma among Puerto Rican Hispanics: a multi-ethnic comparison study of risk factors. *Am J Respir Crit Care Med* 1996;154:894–899.
- Cohen RT, Canino GJ, Bird HR, Shen S, Rosner BA, Celedon JC. Area of residence, birthplace, and asthma in Puerto Rican children. *Chest* 2007;131:1331–1338.
- Hunninghake GM, Weiss ST, Celedón JC. State of the art: asthma in Hispanics. *Am J Respir Crit Care Med* 2006;173:143–163.
- Findley S, Lawler K, Bindra M, Maggio L, Penachio M, Maylahn C. Elevated asthma and indoor environmental exposures among Puerto Rican children of East Harlem. *J Asthma* 2003;40:557–569.
- Ortega A, McQuaid E, Canino G, Ramirez R, Fritz G, Klein R. Association of psychiatric disorders and different indicators of asthma in island Puerto Rican children. *Soc Psychiatry Psychiatr Epidemiol* 2003;38:220–226.
- Rubenfeld AR, Pain MCF. Perception of asthma. *Lancet* 1976;1:882–884.
- Kikuchi Y, Okabe S, Tamura G. Chemosensitivity and perception of dyspnea in patients with a history of near-fatal asthma. *N Engl J Med* 1994;330:1329–1334.
- Chetta A, Gerra G, Foresi A, Zaimovic A, Del Donno M, Chittolini B, Malorgio R, Castagnaro A, Olivieri D. Personality profiles and breathlessness perception in outpatients with different gradings of asthma. *Am J Respir Crit Care Med* 1998;157:116–122.
- Bijl-Hofland I, Cloosterman S, Folgering H, Akkermans R, van Schayck C. Relation of the perception of airway obstruction to the severity of asthma. *Thorax* 1999;54:15–19.
- Creer TL, Marion RJ, Creer PP. Asthma problem behavior checklist: parental perceptions of the behavior of asthmatic children. *J Asthma* 1983;20:97–104.
- Dirks JF, Schraa JC. Patient mislabeling of symptoms and rehospitalization in asthma. *J Asthma* 1983;20:43–44.
- Eisenberg A. Emotion talk among Mexican American and Anglo American mothers and children from two social classes. *Merrill-Palmer Q* 1999;45:264–284.
- Canino G, Koinis Mitchell D, Ortega A, McQuaid E, Fritz G, Alegria M. Asthma disparities in the prevalence, morbidity and treatment of Latino children. *Soc Sci Med* 2006;63:2926–2937.
- Fritz G, McQuaid E, Spirito A, Klein R. Symptom perception in pediatric asthma: relationship to functional morbidity and psychological factors. *J Am Acad Child Adolesc Psychiatry* 1996;35:1033–1041.
- McGrath PA. Psychological aspects of pain perception. *Arch Oral Biol* 1994;39:55s–62s.
- Edwards R, Doleys D, Fillingim R, Lowery D. Ethnic differences in pain tolerance: clinical implications in a chronic pain population. *Psychosom Med* 2001;63:316–323.
- Canino I, Rubio-Stipec M, Canino G, Escobar J. Functional somatic symptoms: a cross-ethnic comparison. *Am J Orthopsychiatry* 1992;62:605–612.
- DuAlba L, Scott R. Somatization and malingering for workers' compensation applicants: a cross-cultural MMPI study. *J Clin Psychol* 1993;49:913–917.
- Zahn-Waxler C, Friedman RJ, Cole PM, Mizuta I, Hiruma N. Japanese and United States pre-school children's response to conflict and distress. *Child Dev* 1996;67:2462–2477.
- Canino G, McQuaid EL, Alvarez M, Colon A, Esteban C, Febo V, Klein RB, Mitchell DK, Kopel SJ, Montealegre F, et al. Issues and methods in disparities research: the Rhode Island–Puerto Rico Asthma Center. *Pediatr Pulmonol* 2009;44:899–908.
- Esteban CA, Klein RB, McQuaid EL, Fritz GK, Seifer R, Kopel SJ, Santana JR, Colon A, Alvarez M, Koinis-Mitchell D, et al. Conundrums in childhood asthma severity, control, and health care use: Puerto Rico versus Rhode Island. *J Allergy Clin Immunol* 2009;124:238–244, 244e1–5.
- Fritz GK, Adams SK, McQuaid EL, Klein R, Kopel S, Nassau J, Mansell A. Symptom perception in pediatric asthma: resistive loading and *in vivo* assessment compared. *Chest* 2007;132:884–889.
- Fritz G, Klein R, Overholser J. Accuracy of symptom perception in childhood asthma. *J Dev Behav Pediatr* 1990;11:69–72.
- Fritz G, Yeung A, Wamboldt M, Spirito A, McQuaid E, Klein R, Seifer R. Conceptual and methodologic issues in quantifying perceptual accuracy in childhood asthma. *J Pediatr Psychol* 1996;21:153–173.
- Klein RB, Walders N, McQuaid EL, Adams S, Yaros D, Fritz GK. The asthma risk grid: clinical interpretation of symptom perception. *Allergy Asthma Proc* 2004;25:1–6.
- U.S. Department of Health and Human Services. The 2005 HHS poverty guidelines. Washington, DC: U.S. Department of Health and Human Services; 2005.
- Global Initiative for Asthma. Global strategy for asthma management and prevention. NIH Publication No. 02-3659. Washington DC: National Heart, Lung, and Blood Institute, National Institutes of Health; 2002.
- Rosier MJ, Bishop J, Nolan T, Robertson CF, Carlin JB, Phelan PD. Measurement of functional severity of asthma in children. *Am J Respir Crit Care Med* 1994;149:1434–1441.
- Koinis Mitchell D, McQuaid E, Seifer R, Kopel S, Esteban C, Canino G, Garcia-Coll C, Klein R, Fritz G. Multiple urban and asthma-related risks and their association with asthma morbidity in children. *J Pediatr Psychol* 2007;32:582–595.
- McQuaid EL, Koinis Mitchell D, Walders N, Nassau JH, Kopel SJ, Klein RB, Wamboldt MZ, Fritz GK. Pediatric asthma morbidity: the importance of symptom perception and family response to symptoms. *J Pediatr Psychol* 2007;32:167–177.

32. Feldman JM, McQuaid EL, Klein RB, Kopel SJ, Nassau JH, Mitchell DK, Wamboldt MZ, Fritz GK. Symptom perception and functional morbidity across a 1-year follow-up in pediatric asthma. *Pediatr Pulmonol* 2007;42:339–347.
33. Koinis Mitchell D, McQuaid E, Seifer R, Kopel S, Nassau J, Klein R, Feldman J, Wamboldt M, Fritz G. Symptom perception in children with asthma: cognitive and psychological factors. *Health Psychol* 2009;28:226–237.
34. Garber J, Walker L, Zeman J. Somatization symptoms in a community sample of children and adolescents: further validation of the Children's Somatization Inventory. *J Consult Clin Psychol* 1991;3:588–595.
35. Penza-Clyve S, Zeman J. Initial validation of the emotion expression scale for children (EESC). *Journal of Clinical Child and Adolescent Psychology* 2002;31:540–547.
36. Kaufman A, Kaufman N. The Kaufman brief intelligence test (K-BIT). 1990 Circle Pines, MN: American Guidance Service.
37. Roisman G, Peiffer C, Lacronique J, Le Cae A, Dusser D. Perception of bronchial obstruction in asthmatic patients: relationship with bronchial eosinophilic inflammation and epithelial damage and effect of corticosteroid treatment. *J Clin Invest* 1995;96:12–21.
38. Salome C, Reddel H, Ware S, Roberts A, Jenkins C, Marks G, Woolcock A. Effect of budesonide on the perception of induced airway narrowing in subjects with asthma. *Am J Respir Crit Care Med* 2002;165:15–21.
39. Tantisira KG, Colvin R, Tonascia J, Strunk RC, Weiss ST, Fuhlbrigge A; Childhood Asthma Management Program Research Group. Airway responsiveness in mild to moderate childhood asthma: sex influences on the natural history. *Am J Respir Crit Care Med* 2008;178:325–331.
40. Lara M, Akinbami L, Flores G, Morgenstern H. Heterogeneity of childhood asthma among Hispanic children: Puerto Rican children bear a disproportionate burden. *Pediatrics* 2006;117:43–53.
41. Rietveld S. Advances in psychosomatic medicine, Vol. 24: Asthma: social and psychological factors and psychosomatic syndromes. Basel, Switzerland: Karger; 2003. pp. 115–130.
42. Todd K, Deaton C, D'Andamo A, Goe L. Ethnicity and analgesic practices. *Ann Emerg Med* 2000;35:11–16.