Pediatric Asthma Morbidity: The Importance of Symptom Perception and Family Response to Symptoms

Elizabeth L. McQuaid,[1] PhD, Daphne Koinis Mitchell,[1] PhD, Natalie Walders,[2] PhD, Jack H. Nassau,[1] PhD, Sheryl J. Kopel,[1] MSc, Robert B. Klein,[1] MD, Marianne Z. Wamboldt,[2] MD, and Gregory K. Fritz,[1] MD

[1]Brown Medical School, and [2]University of Colorado Health Sciences Center

Objective To determine whether family response to asthma symptoms mediates the relationship between child symptom perception and morbidity. **Methods** A total of 122 children with asthma, aged between 7 and 17 years (47% females; 25% ethnic minorities), were recruited from three sites. Participants completed a family asthma management interview and 5–6 weeks of symptom perception assessment. **Results** Family response to symptoms mediated the relationship between child underestimation of symptoms and asthma morbidity and partially mediated the relationship between accurate symptom perception and morbidity. In contrast, although child overestimation of symptoms and family response to symptoms were independently related to asthma morbidity, a mediational model was not supported. **Conclusions** Our study found support for the role of family response to symptoms in mediating the relationship between child symptom perception and morbidity, particularly with regard to underestimation of symptoms, underscoring the need for behavioral tools to accurately recognize and optimally respond to exacerbations.

Key words asthma; family; morbidity.

Pediatric asthma is the most common childhood chronic illness in the US (ALA, 2000). Asthma-related morbidity, or increased symptoms and functional limitation from asthma, continues to pose a significant burden despite increases in our understanding of asthma pathophysiology and ongoing advances in pharmacologic management (NIH, 2002).

The causes of asthma-related morbidity are complex. A multilevel conceptualization incorporating child, family, and system variables appears to best characterize the factors that influence asthma morbidity. Research indicates that various child factors play a role, such as individual physiological variables (e.g., allergic potential), and psychological and perceptual factors, such as the extent to which the child accurately recognizes asthma symptoms (Fritz, McQuaid, Spirito, & Klein, 1996). Family factors, such as how the family manages ongoing symptoms, implements trigger control strategies, and facilitates medication adherence, are also implicated (Fiese & Wamboldt, 2003). System factors, such as insurance coverage and healthcare access, also play a role in asthma outcome (Lieu et al., 2004). Past research has typically studied these areas in isolation, suggesting various correlates of morbidity, but not appreciating the associations between them. This study is an initial attempt to address this shortcoming, by focusing on relations among important child and family factors and morbidity.

The present study investigates whether family response to asthma symptoms mediates the previously established association between child symptom perception and asthma morbidity. The rationale for this hypothesis is based on previous findings relating symptom perception (Fritz, McQuaid et al., 1996) and family factors (Fiese & Wamboldt, 2003) to asthma morbidity and on the clinical understanding that a child's self-care

All correspondence concerning this article should be addressed to Elizabeth L. McQuaid, Brown Medical School, Bradley Hasbro Children's Research center, Corp. West 2, 1 Hoppin St., Providence, Rhode Island 02903. E-mail: emcquaid@lifespan.org.

Journal of Pediatric Psychology 32(2) pp. 167–177, 2007
doi:10.1093/jpepsy/jsj112
Advance Access publication May 22, 2006

of asthma symptoms occurs in the family context (Klinnert, McQuaid, & Gavin, 1997).

Child Factors and Asthma Morbidity: Children's Perceptual Accuracy

Several child factors, including race/ethnicity, disease severity, disease-related behaviors, and psychopathology, are associated with asthma morbidity. Briefly, African-Americans and Latinos generally have greater functional limitation, higher healthcare utilization, and increased mortality rates from asthma (Lara et al., 2002). Additionally, children with psychopathology and greater disease severity have greater morbidity (ten Brinke, Ouwerkerk, Zwinderman, Spinhoven, & Bel, 2001). Children with poor medication adherence also have higher asthma morbidity (McQuaid, Kopel, Klein, & Fritz, 2003).

A growing area of research has assessed the association between children's abilities to recognize asthma symptoms and morbidity. Symptom perception is an important area of investigation because recognition of symptoms can be viewed as the first step in a chain of events that lead to either effective or maladaptive asthma management. Children demonstrate wide variability in symptom perception accuracy (Fritz, McQuaid et al., 1996); yet the factors that explain this variability are not well understood. In one study, researchers found asthma symptom perception to be inaccurate in many children in their sample, independent of severity, age, gender, and use of preventive medication (Cabral, Conceicao, Saldiva, & Martins, 2002). Some research suggests that cognitive factors, such as intelligence, may play more of a role than emotional factors, such as anxiety and depression (Fritz, McQuaid et al., 1996). Research does demonstrate that children who fail to perceive asthma compromise are at risk for greater morbidity (Fritz, McQuaid et al., 1996; Yoos & McMullen, 1999).

These findings suggest that children's perception of asthma symptoms is a critical component in the asthma management process. Still, there is a limited understanding of the pathway by which child symptom perception is associated with asthma morbidity. We propose that how a child's family responds to the identification of asthma symptoms may be an important mediator of the association between child symptom perception and asthma morbidity.

The Family Response to Asthma Symptoms: A Potential Mediating Role

National guidelines for asthma diagnosis and management continue to emphasize the roles of patients and families in disease control (NIH, 1997, 2002). Lessening asthma morbidity is a challenging and complex task for families, involving a range of behaviors including identifying and responding to symptoms, adhering to multiple medications, and avoiding a range of allergens and asthma triggers. A growing body of research has assessed children's asthma management by quantifying adherence to preventive medications for asthma (Bender et al., 2000). Given the episodic nature of asthma symptoms, both the child's skill in identifying asthma symptoms and the family's ability to enact an appropriate symptom management plan may also be critical, yet understudied pathways to decreasing morbidity.

Studies of the association between family processes and asthma outcomes have emphasized the role of broad familial and cultural factors rather than specific asthma management behaviors (see Kaugars, Klinnert, & Bender, 2004 for a review). Certain aspects of the parent–child relationship, such as negative effect and criticism, are related to greater asthma morbidity (Hermanns, Florin, Dietrich, Rieger, & Hahlweg, 1989; Schobinger, Florin, Zimmer, Lindemann, & Winter, 1992). Some parent-specific factors, such as maternal depression, are also associated with greater asthma morbidity (Shalowitz, Berry, Quinn, & Wolf, 2001). Recent research suggests that this particular association may be mediated by medication adherence, such that mothers who are depressed may have more difficulty facilitating their children's regular adherence to asthma medications (Bartlett et al., 2004). Clarity regarding the distribution of asthma management tasks between family members is related to reports of better adherence and decreased morbidity (Walders, Drotar, & Kercsmar, 2000). Additionally, family approaches to asthma management, when assessed by qualitative parent interviews, relate to concurrent and prospective indicators of medical adherence and healthcare utilization (Fiese & Wamboldt, 2003). Specifically, families who reported patterns of asthma management that could be classified as "reactive" had lower medication adherence and greater emergent healthcare utilization at 1-year follow-up.

In summary, the available literature suggests that family processes and asthma management strategies play an instrumental role in influencing asthma morbidity. Little is known, however, about how family factors function in concert with child factors to predict morbidity. We propose a conceptual model that begins with appropriate identification of early warning signs and symptoms through the child's own symptom assessment (Fig. 1). We hypothesize that the association between the child's symptom assessment and outcome (i.e., morbidity) is

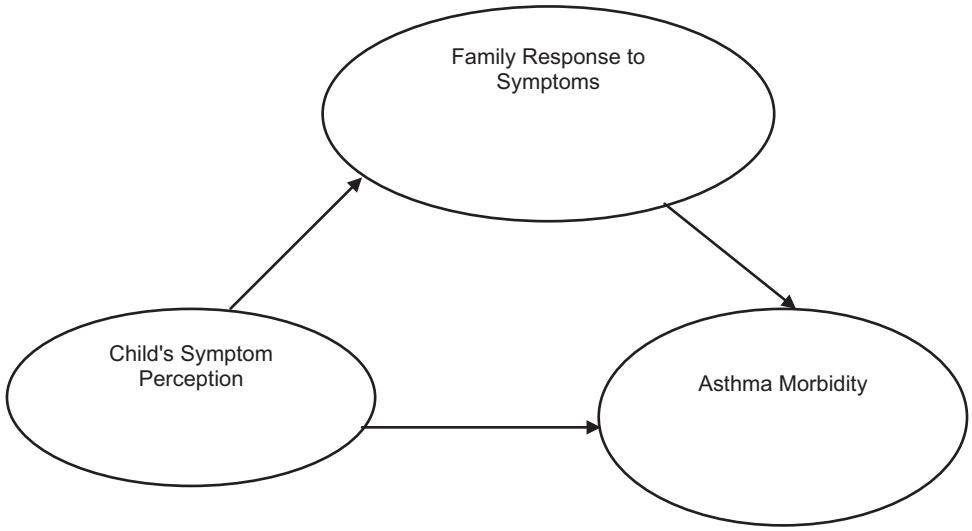

Figure 1. Conceptual model.

mediated through the family response to asthma symptoms. In this model, the family response to symptoms is defined as the quality and coherence of the specific behaviors implemented by the family when the child reports asthma symptoms.

We utilized a naturalistic evaluation of child symptom perception and an empirically validated, interview-based assessment of the family response to asthma symptoms (McQuaid, Walders, Kopel, Fritz, & Klinnert, 2005) to empirically examine our model. We defined asthma morbidity as the extent to which asthma impacts children's daily functioning, through both increased symptoms and activity limitation.

Methods

Participants

Families were recruited for participation through flyers, physician referrals, and summer camps for children with asthma. Study eligibility requirements included children aged between 7 and 17 years and physician-diagnosed asthma for at least 6 months before study enrollment. Children with other significant pulmonary conditions (e.g., cystic fibrosis) or with significant cognitive delays identified during screening (as defined by parental report of the child being placed in a special education classroom) that might preclude understanding of the symptom perception protocol were not eligible. Participants included 122 children with asthma and a primary caregiver for their asthma, most commonly the mother (92%), but occasionally the father (6%) or grandmother (2%). Children's age ranged from 7 to 17 years (X = 11.6, SD = 2.3). Forty-seven percent of child participants were females. Most primary caregivers (75%) identified their child's racial/ethnic background as white, with the remainder described as African-American/Black (11%), White Hispanic (6%), or Biracial (7%).

Data were collected at three national sites. No site differences were found in terms of child age, $F(2,122) = 1.34$, *ns*; parental occupational prestige, $F(2,114) = 0.13$, *ns*; or distribution of gender ($\chi^2 = 3.83$, *ns*), ethnicity ($\chi^2 = 11.64$, *ns*), or asthma severity ($\chi^2 = 8.90$, *ns*).

Procedures

Written parental consent and child assent were obtained in accordance with Institutional Review Board guidelines for all the three sites. Study participation involved the following three components: (a) completion of self-report measures by the caregiver; (b) administration of a standard semistructured interview to assess family asthma management; and (c) participation in a 5- to 6-week symptom perception assessment using a programmable, electronic spirometer (AMII, Jaeger). During an initial laboratory visit, children and caregivers completed self-report measures and participated in the Family Asthma Management System Scale interview (FAMSS; Klinnert et al., 1997; McQuaid et al., 2005). At the end of the visit, children were oriented to the use of the AMII. All measures and methods are described in detail. For the remainder of the article, we will use "parent" to refer to the primary asthma caregiver participating in the study.

Self-Report Measures

Demographic Information

Parents completed a general demographic questionnaire that included information regarding child age, race/ethnicity, medications prescribed for the child's asthma,

and parental occupation. Occupational prestige scores as an indicator of a family's socioeconomic status have been widely used in studies that include diverse samples of healthy children (Luster & McAdoo, 1996) and children with chronic illnesses (Anderson, Anderson, Grimwood, & Nolan, 2004). In this study, each parent's occupational prestige was classified according to the National Opinion Research Council (NORC) coding system (Nakao & Treas, 1992). This rating system assigns a "prestige" score to each occupation, with higher scores indicating more prestigious occupations. In this study, when both parents worked, the highest rating for the family parental occupation was used. Ratings of family's primary occupations ranged from 24.30 (maid/houseman) to 86.05 (physician), with an average rating of 52.82.

Asthma Functional Morbidity

Parents completed the Asthma Functional Severity Scale (AFSS), which assesses the degree of functional impairment that asthma imposes on children's daily functioning (Rosier et al., 1994). The AFSS examines four components of children's asthma morbidity, including frequency of episodes, frequency of symptoms between episodes, intensity of impairment during an episode, and intensity of impairment during the intervals between episodes. The functional morbidity index score is calculated by computing a mean across all completed items, with higher scores indicating greater levels of impairment. In this study, questions were asked with reference to the past year. The AFSS was developed on a sample of more than 10,000 children; the index score is significantly correlated with school absences, medical visits for asthma, and medication use (Rosier et al., 1994).

Asthma Severity Ratings

Background information used to assess disease severity was obtained from the parental report. This included prescribed medications and dosing as well as information describing the child's functional impairment (e.g., how many days of school were missed due to asthma in the past year?) that was obtained from a standard questionnaire. Upon review of this information, a pediatric asthma specialist (R.B.K.) assigned each child an asthma severity rating, from 1 (mild intermittent) to 4 (severe persistent), using NIH (1997) criteria. By this method, 10% of children were categorized as having mild intermittent asthma, 56% mild persistent, 28% moderate persistent, and 6% severe persistent.

Symptom Perception Assessment

The symptom perception assessment involved a series of repeated subjective peak expiratory flow rate (PEFR) guess and objective (PEFR value) observations for each child over the course of approximately 5–6 weeks of data collection. The PEFR represents the maximum rate of airflow during forced expiration and is a standard measure of current asthma status (NIH, 1997). Children were directed to make repeated subjective assessments by guessing their peak flow value and inputting their guess into the AMII, then blowing into the AMII directly afterward to generate an objective assessment of lung function. Children were oriented to the use of the AMII at the baseline visit. They first observed a trained research assistant execute a blow using maximal effort and then were asked to demonstrate the use of the AMII to the research assistant. Corrective feedback was provided if necessary. Children were also oriented to the computer function keys, including how to input a peak flow guess in response to the computer prompt ("Guess your peak flow"). The program restricted children from doing a PEFR until they had inputted their "guess," and all events were time stamped. Children were instructed to use the AMII twice daily. Families received two to three "reminder calls" to monitor device quality control and to prompt consistent usage. AMII's were collected at the end of the 5- to 6-week time period at another study visit.

Symptom Perception: Data Reduction

An Asthma Risk Grid (Feldman et al., 2005; Fritz, Yeung et al., 1996; Klein et al., 2004) was used to quantify each child's symptom perception ability. By this method, the multiple subjective (PEFR guesses) and objective (actual PEFR values) are summarized to provide a pattern of perceptual ability. PEFR guess values and actual values were first converted to "percent of personal best" by dividing by the highest PEFR value obtained during the data collection period (the personal best) and multiplying by 100. Risk Grids were then constructed for each participant (Fig. 2).

The horizontal axis of the Risk Grid represents the objective peak flow measurement, and the vertical axis represents the child's guess of the peak flow value. The accurate zone of the Risk Grid indicates a subjective assessment that corresponds appropriately to objective clinical status. It includes (a) a "wedge" in which the estimate is ±10% of the actual value; (b) boxes 1 and 5 in which compromise below 50 and 80% of personal best is recognized as such; and (c) box 9 in which adequate function (above 80% of personal best) is recognized. The danger zone includes points that fall in boxes 4, 7, and 8, where clinically significant compromised function (below 80% of personal best) is not recognized

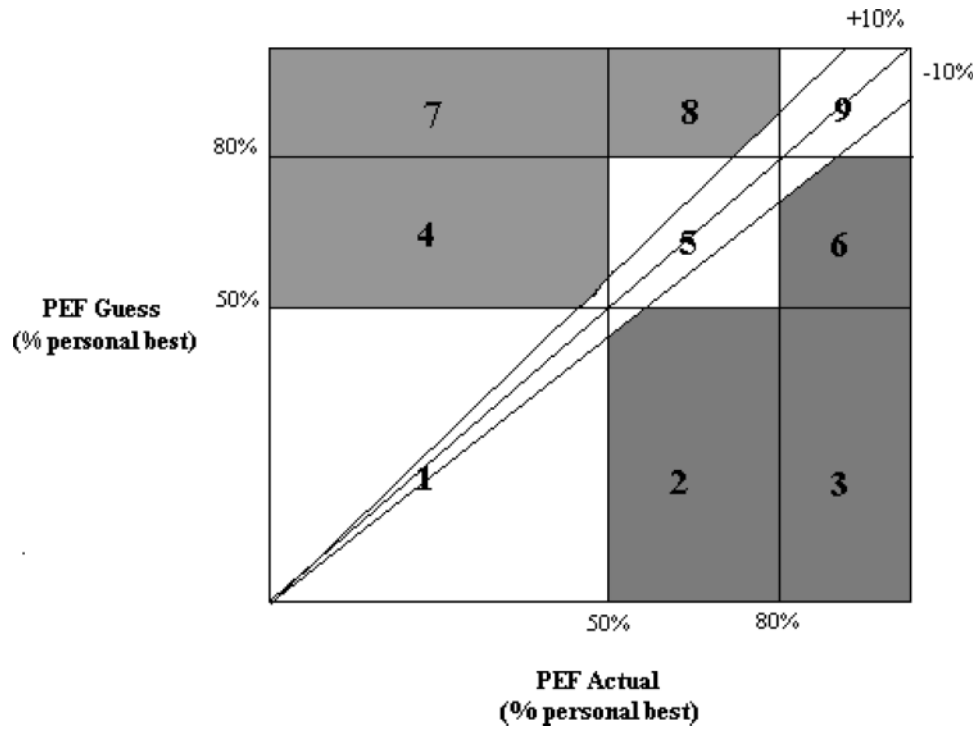

Figure 2. Asthma Risk Grid. Accurate zone: boxes 1, 5, 9, and +/– 10% wedge; danger zone: boxes 4, 7, and 8; symptom magnification zone: boxes 2, 3, and 6. Reproduced from Klein et al. (2004) The Asthma Risk Grid: Clinical Interpretation of System Perception. Allergy and Asthma Proceedings, 25, 1–6. Oceanside Publications, Inc.

by the patient. The symptom magnification zone includes boxes 2, 3, and 6 and reflects oversensitivity to minor symptoms or exaggeration of symptoms. All indices have been found to relate to asthma morbidity as measured by the AFSS (Feldman et al., 2005).

FAMSS Interview

The FAMSS is a semistructured interview comprised of a series of open-ended questions that are designed to assess key areas of asthma management (Klinnert et al., 1997; McQuaid et al., 2005). Family members are also asked to provide ratings regarding certain specific content areas (e.g., "On a five-point scale from 1 = very uncomfortable to 5 = very comfortable, how comfortable do you feel asking your child's doctor questions about asthma?"). Parents and children participate together, because with increasing age children are often able to provide unique perspectives with regard to asthma management in contexts outside the home. In the present study, families were asked to consider behavior over the past year. All interviews were audiotaped for rating purposes.

FAMSS interviews were rated using a standard manual that provides rating instructions and a series of rating guidelines for each scale. Each scale is given a nine-point rating, from 1 (ineffective or harmful management) to 9 (highly adaptive management). The rating scale is constructed to help the rater account for developmental variations in appropriate child involvement in asthma management by providing examples at certain key anchor points. Ratings are conducted immediately after the interview or after a review of the audiotape. For the present study, all interviewers and raters were trained in administration and scoring through consensus meetings with the original authors of the interview. Further detail regarding this process can be found in another article (McQuaid et al., 2005). Although the entire interview was administered and rated, for the present study we focus specifically on one scale, Family Response To Symptoms. During the interview, the family is asked to provide a step-by-step description of what they do when the child has symptoms, including how and when they initiate treatment, how they decide whether a treatment is working, and when they would call a healthcare provider or seek urgent care. The family response subscale of the FAMSS was related to a parental asthma knowledge, child self-efficacy to manage episodes, and an objective index of medication adherence (McQuaid et al., 2005).

All interviews were rated by one of two primary interviewers who were blinded to the results of the other study assessments. Scores on the Family Response to Symptoms subscale ranged from 1 to 9 (X = 6.2, SD = 1.6). A subset of audiotapes (n = 38) were rated by both raters

in the context of biweekly consensus meetings. The intraclass correlation between raters was .84.

Results

Preliminary Analyses

Data transformations were applied to variables unlikely to conform to assumptions of normality and homogeneity of variance. Specifically, probit transformations, which normalize distributions of proportional variables (Cohen & Cohen, 1983), were applied to all zone scores (accurate zone, symptom magnification zone, and danger zone), as they are proportions. Raw scores were retained for sample description.

Symptom Perception

For a child's data to be included in the analyses, a minimum of 20 subjective/objective-paired recordings were necessary across the 5- to 6-week symptom perception assessment, because "20" was judged to be the minimum number necessary to provide reliable estimates of summary index scores through extensive data examination. Twelve participants were excluded from the data set by this criterion. These participants were not different from the remaining participants in terms of child age, $t(2,120) = 1.06$, *ns*; socioeconomic status as represented by NORC ratings, $t(2,112) = -.003$, *ns*; or asthma severity ($\chi^2 = 2.61$, *ns*). A higher proportion of children whose caretakers identified them as being of ethnic minority status data were excluded by this criterion ($\chi^2 = 9.56$, $p < .05$), with 8 of 12 excluded cases being from minority children.

For the subjects who remained, Risk Grids were applied to the data as described. Risk Grids were based on an average of 48 data point pairs (subjective guess and objective lung function data), with a range across subjects of 21–122 data points. Results indicated that across all participants, most blows were in the accurate zone ($X = 76.2\%$, range = 3.3–100%) and fewer blows were in the symptom magnification zone ($X = 14.5\%$, range = 0–96.7%) and danger zones ($X = 9.3\%$, range = 0–78.1%). It is important to note, however, that there was a considerable range of scores across participants and zones.

Mediational Analyses

A mediator is often described as the mechanism through which one variable exerts its influence on another (Baron & Kenny, 1986). We propose that the family response to asthma symptoms mediates the relationship between symptom perception and morbidity. In other words, the child's symptom perception influences the family response to symptoms, which then influences asthma outcomes. According to Baron & Kenny (1986), three statistical conditions must be satisfied to provide support for a mediational model. First, the predictor variable (symptom perception) must be significantly associated with the mediator (family response to symptoms). Second, the predictor variable (symptom perception) must be associated with the outcome (asthma morbidity). Last, the mediator variable (family response to symptoms) must be associated with the outcome variable (asthma morbidity). If the addition of the mediator to the full model reduces the relationship between the predictor and outcome (i.e., the mediator accounts for this association), then mediation has been demonstrated.

The steps for testing for mediation were followed for each of the specific symptom perception variables (proportion of scores in the accurate zone, symptom magnification zone, and danger zone). Asthma severity, which was significantly associated with asthma morbidity, $F(3,104) = 9.00$, $p < .001$, was entered as a covariate in any regression predicting morbidity. Race/ethnicity, child age, and occupational prestige were not significantly associated with morbidity; hence, they were not included in the model.

Figure 3a presents the results of mediational analyses for dangerous symptom perception (DSP, representing the proportion of scores in the danger zone). DSP was negatively associated with the family response to symptoms [$r = -.27$, $p < .05$, pathway (a)]. Family response to symptoms was negatively associated with asthma morbidity [$r = -.46$, $p < .01$, pathway (b)]. DSP was significantly associated with asthma morbidity [$r = .18$, $p < .05$, pathway (c)]. This relationship, however, was significantly reduced when the mediator, family response to asthma symptoms, was entered into the model ($\beta = .05$, *ns*). This effect was tested using the product of coefficients method outlined in MacKinnon, Lockwood, Hoffman, West, & Sheets (2002) and was found to be statistically significant ($P = Z\alpha Z\beta = 14.71$, $p < .05$). The combined model accounted for 35% of the variance in asthma morbidity.

Figure 3b presents a similar set of analyses to test for mediation for symptom magnification (SM, indicating the proportion of scores in the symptom magnification zone). The SM index was not found to be associated with the family response to asthma symptoms; hence, criteria for mediation were not met. The entire model, however, accounted for 38% of the variance in asthma morbidity, suggesting each of these variables (i.e., SM and family response to symptoms) exerts some independent effects on asthma morbidity.

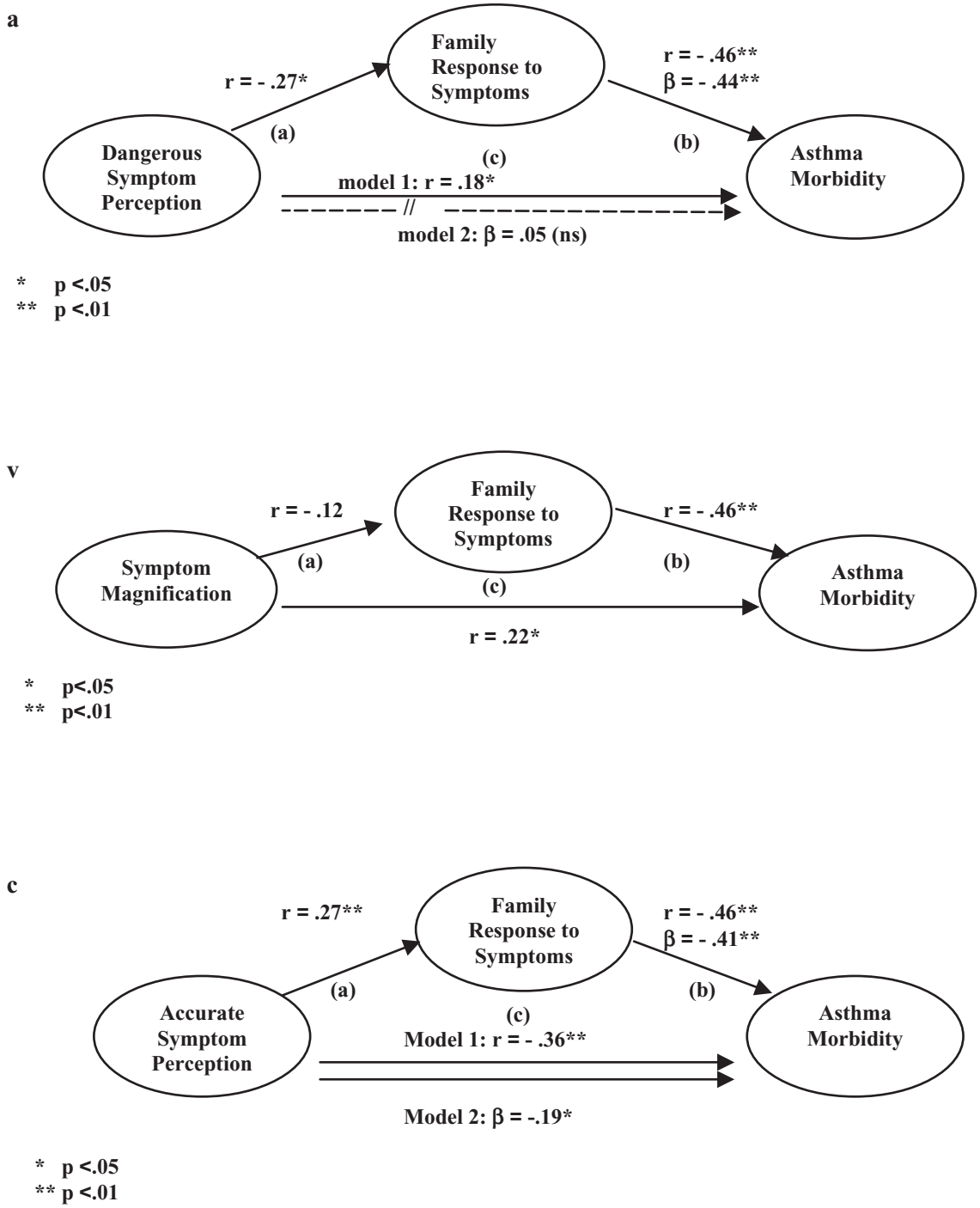

Figure 3. Mediational models. (**a**) Dangerous symptom perception. (**b**) Symptom magnification. (**c**) Accurate symptom perception.

Figure 3c depicts the results of regression analyses to test whether the relationship between accurate symptom perception (ASP, representing the proportion of scores in the accurate zone) and asthma morbidity is mediated by the family response to symptoms. ASP was positively associated with the family response to symptoms [r = .27, p < .05, pathway (a)]. As in the previous models, family response to symptoms was negatively associated with asthma morbidity [r = –.46, p < .01, pathway (b)]. ASP was significantly associated with asthma morbidity [r = –.36, p < .01, pathway (c)]. This relationship, however, was reduced when the mediator, family response to asthma symptoms, was entered into the model (β = .19, p < .05). Of note, although the mediator

reduced the size of the direct effect, it did not reduce this effect to a nonsignificant value, indicating partial mediation. The mediation effect was also statistically significant by the product of coefficients method ($P = Z\alpha Z\beta = 14.49$, $p < .01$). The full model accounted for 39% of the variance in asthma morbidity.

Discussion

Much of behavioral research in pediatric asthma assesses discrete individual (e.g., maternal depression) or family level (e.g., conflict and parental criticism) variables in attempting to understand how psychological factors relate to asthma outcomes. Although a few conceptual models exist that attempt to explain how individual and family variables relate to asthma outcomes (e.g., Creer, 2000; Koinis Mitchell, Murdock, & McQuaid, 2004), relatively little empirical work has sought to assess the pathways through which individual and family level asthma management variables explain asthma morbidity. The present study attempted to address this gap in the literature by examining whether the link between children's perception of asthma symptoms and asthma morbidity was mediated by the family response to asthma symptoms.

We employed a method of assessing children's symptom perception accuracy that enabled us to pair children's subjective assessments of their asthma status with objective lung function data over 5–6 weeks. This method of data was more naturalistic than previous methods (e.g., Fritz et al., 1996), because it allowed for symptom perception assessment in the context of the children's home settings. The use of a validated semistructured interview to capture information regarding how the family typically responds to asthma symptoms and the steps that they implement for ongoing management improves upon typical methods of assessing asthma management, such as parental proxy report. Finally, a mediational approach allowed us to move beyond confirming the relationship between symptom perception and asthma morbidity by evaluating a potential pathway responsible for this association.

Our findings indicated that a tendency to underestimate asthma symptoms was associated with concurrent asthma morbidity, although only modestly. The child's ability to accurately identify pulmonary function compromise, or lack of symptoms, was related to decreased morbidity. A pattern of oversensitivity to symptoms, or tendency to perceive greater compromise than actually existed, was also related to asthma morbidity.

Our results provide some support for models in which the link between child symptom perception and morbidity is mediated through the family's general response to symptoms. Specifically, the link between dangerous symptom perception and morbidity was mediated through the family response to asthma symptoms. This suggests that when children demonstrate a pattern of underestimating the severity of their asthma status, it is generally linked to an inadequate family plan for managing asthma symptoms. Poor family response to asthma symptoms was associated with asthma morbidity and, in effect, "explained" the association between symptom perception and outcome. A pattern of ineffective and inappropriate response to asthma symptoms on the part of a family may result in a child's dulled ability to accurately perceive his or her symptom status and may develop into a tendency to neglect emerging exacerbations on the part of the child. Alternatively, a child's consistent failure to perceive symptoms may result in ineffective family response patterns and increased asthma morbidity.

Similarly, accurate symptom perception was associated with a more functional response to asthma symptoms on the family level, indicating that children who were more accurate at detecting asthma symptoms (or lack thereof) have a more functional family response to symptoms that will enable them to get appropriate treatment. Interestingly, the degree to which a child overestimated symptoms (i.e., guessed their compromise was greater than it was) was not linked to the quality of family response to symptoms but was related to morbidity. This finding suggests that there may be some children who are more sensitized to their asthma symptoms, and their parents, in turn, report greater functional limitation. This association, however, is not explained by the family response to symptoms. It is possible that some children and families are more hyperperceptive of minor changes in the child's asthma status and also report a greater level of symptoms, but this is not necessarily related to any discernible pattern in the family response to symptoms. For example, some families may respond with inappropriate alarm, and others may respond appropriately and only utilize health care when symptoms are significant by some objective standard, such as a PEFR measurement. This could result in the lack of relationship between overestimation of symptoms and family response, as found in our data.

There are several limitations to this study that deserve mention. Our assessment of asthma severity was not verified by chart review of medications or healthcare utilization. Our morbidity index was not prospective

and was based on parental report. Recent research, however, indicates that parental report of asthma symptoms may depict asthma status as well as spirometry (Sharek et al., 2002). Our FAMSS interview and assessment of asthma morbidity were conducted with reference to the prior year, and our symptom perception assessment was conducted during the study period; hence, the time periods of the first two assessments did not correspond to those of the symptom perception assessment. Given the dynamic nature of asthma, it is possible that our symptom perception protocol failed to capture a representative sampling of asthma symptoms, which may have attenuated the associations amongst variables.

Further, our assessment of symptom perception is dependent on some familiarity with peak flow use. Our experience is that in general, children are able to learn this skill quickly with the coaching and feedback implemented in our orientation. PEFR measurements are effort dependent, however, and poor effort is difficult to detect in our protocol, given that the children conducted their peak flow blows in the home setting. Children were not perfectly adherent to the protocol, and fewer data points may have compromised the reliability of our symptom perception assessment. Children whose data were excluded due to poor protocol compliance (too few PEFR blows) may have been systematically different in certain ways (e.g., a poor family response to symptoms). A longer period of data collection (e.g., 2–3 months) could have provided more opportunity for PEFR compromise and may also have provided more reliable estimates of symptom perception. Additionally, the Asthma Risk Grid has not been validated extensively across demographic groups. Despite these limitations, we did find consistent, although modest, associations between symptom perception and asthma morbidity.

All of our analyses, based on regression modeling, document associations amongst variables and do not necessarily represent causal connections. Bidirectional associations likely exist between many variables, such as symptom perception variables and the family response to symptoms. Longitudinal designs, planned for future work, will more accurately assess the extent to which childhood symptom perception is linked to family response to asthma symptoms and subsequent asthma outcomes. Given that our sample was only 25% minority, and largely children with mild persistent disease, findings may not generalize to children with more diverse backgrounds and/or more severe asthma.

As our data indicated, symptom perception is variable across children. Family responses may well differ depending upon how children perceive and express their symptoms. Future research should examine whether family response patterns to children's symptom perception remain stable or vary across time according to fluctuations in symptom severity. Additionally, future research should assess the extent to which developmental transitions (e.g., the transition to high school or college) could be critical junctures for the disruption of individual and family-based asthma management strategies.

Our study raises several interesting questions. For example, what types of cultural beliefs or socioeconomic variables are related to individual symptom perception and family asthma management strategies, and are these potential treatment targets? Studies with larger samples incorporating specific cultural groups are needed to address these questions. Factors within the larger healthcare system, such as insurance coverage and access to health care, are also likely to affect a family's decision-making regarding asthma management strategies and related outcomes. Specifically, there is evidence that insurance coverage is a predictor of access to care for asthma treatment (Stoddard, St. Peter, & Newacheck, 1994). Studies testing models that incorporate larger contextual factors are necessary for a fuller model of asthma management.

The results of this study emphasize the clinical importance of obtaining a rich behavioral assessment of family-based asthma management practices and intervening at both the child and family levels to reduce morbidity. Our findings suggest that intervention should expand beyond imparting increased asthma knowledge and instead provide children and families with concrete and explicit tools for enhancing symptom perception skills and improving family-based strategies for responding to exacerbations. A clear, specific focus on how the family manages asthma symptoms when they occur could lead to more accurate and effective symptom appraisal, more timely treatment, and reductions in asthma morbidity.

Acknowledgments

This study was supported by American Lung Association Grant CI-002-N and the following grants from the NIH: R03 HD 370235, R01 HL45157, and M01 RR00051: General Clinical Research Centers Program.

Received September 2, 2005; revision received January 8, 2006; accepted March 7, 2006

References

ALA. (2000). *Trends in Asthma Morbidity and Mortality: Epidemiology and Statistics Unit*. New York: American Lung Association.

Anderson, V., Anderson, P., Grimwood, K., & Nolan, T. (2004). Cognitive and executive function 12 years after childhood bacterial meningitis: effect of acute neurologic complications and age of onset. *Journal of Pediatric Psychology*, *29*, 67–81.

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, *51*, 1173–1182.

Bartlett, S. J., Krishnan, J. A., Riekert, K. A., Butz, A. M., Malveaux, F. J., & Rand, C. S. (2004). Maternal depressive symptoms and adherence to therapy in inner-city children with asthma. *Pediatrics*, *113*, 229–237.

Bender, B., Wamboldt, F. S., O'Connor, S. L., Rand, C., Szefler, S., Milgrom, H., et al. (2000). Measurement of children's asthma medication adherence by self report, mother report, canister weight, and Doser CT. *Annals of Allergy, Asthma and Immunology*, *85*, 416–421.

Cabral, A., Conceicao, G. M., Saldiva, P. H., & Martins, M. A. (2002). Effect of asthma severity on symptom perception in childhood asthma. *Brazilian Journal of Medical and Biological Research*, *35*, 319–327.

Cohen, J., & Cohen, P. (1983). *Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Creer, T. L. (2000). Self-management and the control of chronic pediatric illness. In D. Drotar (Ed.), *Promoting adherence to medical treatment in chronic illness: Concepts, methods, and interventions* (pp. 95–130). Mahwah, NJ: Lawrence Erlbaum Associates.

Feldman, J., Fritz, G. K., McQuaid, E. L., Kopel, S. J., Klein, R. B., Mansell, A., et al. (2005). *Symptom perception and asthma morbidity in pediatric asthma*. Paper presented at the International Society for the Advancement of Respiratory Psychophysiology, Hamburg, Germany.

Fiese, B. H., & Wamboldt, F. S. (2003). Tales of pediatric asthma management: family-based strategies related to medical adherence and health care utilization. *Journal of Pediatrics*, *143*, 457–462.

Fritz, G. K., McQuaid, E. L., Spirito, A., & Klein, R. B. (1996). Symptom perception in pediatric asthma: Relationship to functional morbidity and psychological factors. *Journal of the American Academy of Child and Adolescent Psychiatry*, *35*, 1033–1041.

Fritz, G. K., Yeung, A. G., Wamboldt, M. Z., Spirito, A., McQuaid, E. L., Klein, R., et al. (1996). Conceptual and methodologic issues in quantifying perceptual accuracy in childhood asthma. *Journal of Pediatric Psychology*, *21*, 153–173.

Hermanns, J., Florin, I., Dietrich, M., Rieger, C., & Hahlweg, K. (1989). Maternal criticism, mother–child interaction, and bronchial asthma. *Journal of Psychosomatic Research*, *33*, 469–476.

Kaugars, A. S., Klinnert, M. D., & Bender, B. G. (2004). Family influences on pediatric asthma. *Journal of Pediatric Psychology*, *29*, 475–491.

Klein, R. B., Walders, N., McQuaid, E. L., Adams, S., Yaros, D., & Fritz, G. K. (2004). The Asthma Risk Grid: clinical interpretation of symptom perception. *Allergy and Asthma Proceedings*, *25*, 1–6.

Klinnert, M. D., McQuaid, E. L., & Gavin, L. A. (1997). Assessing the family asthma management system. *Journal of Asthma*, *34*, 77–88.

Koinis Mitchell, D., Murdock, K. K., & McQuaid, E. L. (2004). Risk and resilience in urban children with asthma: A conceptual model and exploratory story. *Children's Health Care*, *34*, 275–298.

Lara, M., Rosenbaum, S., Rachelefsky, G., Nicholas, W., Morton, S. C., & Emont, S. (2002). Improving childhood asthma outcomes in the United States: a blueprint for policy action. *Pediatrics*, *109*, 919–930.

Lieu, T. A., Finkelstein, J. A., Lozano, P., Capra, A. M., Chi, F. W., Jensvold, N., et al. (2004). Cultural competence policies and other predictors of asthma care quality for Medicaid-insured children. *Pediatrics*, *114*, 102–110.

Luster, T., & McAdoo, H. (1996). Family and child influences on educational attainment: A secondary analysis of the high/scope Perry preschool data. *Developmental Psychology*, *32*, 26–39.

MacKinnon, D. P., Lockwood, C. M., Hoffman, J. M., West, S. G., & Sheets, V. (2002). A comparison of methods to test the significance of the mediated effect. *Psychological Methods*, *7*, 83–104.

McQuaid, E. L., Kopel, S. J., Klein, R. B., & Fritz, G. K. (2003). Medication adherence in pediatric asthma: Reasoning, responsibility, and behavior. *Journal of Pediatric Psychology*, *28*, 323–333.

McQuaid, E. L., Walders, N., Kopel, S. J., Fritz, G. K., & Klinnert, M. D. (2005). Pediatric asthma management in the family context: The family asthma management system scale. *Journal of Pediatric Psychology*, *30*, 492–502.

Nakao, K., & Treas, J. (1992). *The 1989 Socioeconomic Index Occupational Prestige Scores. GSS Methodological Report No. 74*. Chicago: University of Chicago (NORC), May 1992.

NIH. (1997). *National Asthma Education and Prevention Program (National Heart, Lung, and Blood Institute) Second Expert Panel on the Management of Asthma. Expert panel report 2: Guidelines for the Diagnosis and Management of Asthma*. Bethesda, MD: National Institutes of Health.

NIH. (2002). *NAEPP Expert Panel Report: Guidelines for the Diagnosis and Management of Asthma-Update of Selected Topics 2002*. National Institutes of Health.

Rosier, M. J., Bishop, J., Nolan, T., Robertson, C. F., Carlin, J. B., & Phelan, P. D. (1994). Measurement of functional severity of asthma in children. *American Journal of Respiratory and Critical Care Medicine*, *149*, 1434–1441.

Schobinger, R., Florin, I., Zimmer, C., Lindemann, H., & Winter, H. (1992). Childhood asthma: paternal critical attitude and father–child interaction. *Journal of Psychosomatic Research*, *36*, 743–750.

Shalowitz, M. U., Berry, C. A., Quinn, K. A., & Wolf, R. L. (2001). The relationship of life stressors and maternal depression to pediatric asthma morbidity in a subspecialty practice. *Ambulatory Pediatrics*, *112*, 185–193.

Sharek, P., Mayer, M., Loewy, L., Robinson, T., Shames, R., Umetsu, D., et al. (2002). Agreement among measures of asthma status: a prospective study of low-income children with moderate to severe asthma. *Pediatrics*, *110*, 797–804.

Stoddard, J. J., St. Peter, R. F., & Newacheck, P. W. (1994). Health insurance status and ambulatory care for children. *New England Journal of Medicine*, *330*, 1421–1425.

ten Brinke, A., Ouwerkerk, M. E., Zwinderman, A. H., Spinhoven, P., & Bel, E. H. (2001). Psychopathology in patients with severe asthma is associated with increased health care utilization. *American Journal of Respiratory and Critical Care Medicine*, *163*, 1093–1096.

Walders, N., Drotar, D., & Kercsmar, C. (2000). The allocation of family responsibility for asthma tasks in African-American adolescents. *Journal of Asthma*, *37*, 89–99.

Yoos, H. L., & McMullen, A. (1999). Symptom monitoring in childhood asthma: How to use a peak flow meter. *Pediatric Annals*, *28*, 31–39.