

Uncontrolled asthma and factors related to morbidity in an impoverished, rural environment

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ABSTRACT

Background: Asthma disproportionately affects children living in impoverished communities; however, factors related to asthma morbidity among impoverished rural children have not been adequately described. **Objective:** To examine factors associated with asthma morbidity among rural children living in the Arkansas Delta region.

Methods: We performed a cross-sectional investigation of 109 rural children with asthma enrolled in public schools in the Arkansas Delta region. A questionnaire format and home inspection were used to examine participant, caregiver, and home characteristics.

Results: The median age of the study participants was 9 years, 83% were African American, and 71% had an annual household income of \$20,000 or less. Ninety-eight percent of participants were insured, and most fit the criteria for uncontrolled asthma, yet only 23% reported taking inhaled corticosteroids. Transportation problems were cited by 20%. In the past 4 weeks, more than 50% reported rescue medication use or exercise limitations of 2 or more days per week or nocturnal symptoms of more than 2 nights per month. Emergency department visits in the past 6 months were reported by 28%, and 43% reported an unscheduled physician's visits for asthma in the past 3 months. Sixty-four percent had 1 or more positive allergen skin test results, and allergic sensitization was associated with exposure to dust mite, dog, mouse, and cockroach allergens in the home.

Conclusions: Asthma morbidity was high among this cohort of atopic asthmatic children in the Arkansas Delta. Overuse of rescue medications and underuse of inhaled corticosteroids were prevalent even though the population was highly insured and had frequent health care use. Future asthma health initiatives should focus on the unique challenges associated with translating national guidelines-based care to rural pediatric populations.

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Introduction

Poorly controlled asthma among minority populations has been well described for children living in densely populated regions, particularly those living in inner-city environments.^{1–3} Investigators have found that these children frequently report increased asthma morbidity compared with children from more affluent environments. Underlying causes of these disparities are not fully understood, yet there are clearly multiple barriers to improving asthma outcomes among high-risk children, including inadequate health care access,⁴ inadequate health insurance,⁵ physician-pa-

tient relationship barriers,⁶ environmental exposures,^{7–9} social factors,¹⁰ and individual and family health behavior and attitudes.^{11,12}

Despite strong evidence of increased asthma prevalence and severity among minority and low-income populations, few publications examine low-income and/or minority populations living in rural environments. We previously reported increased asthma prevalence among children living in rural Arkansas¹³ and examined differences in asthma prevalence and morbidity among rural and urban children.¹⁴ We found that compared with urban children, rural children living in the Mississippi Delta region had more severe asthma and were more likely to report uncontrolled symptoms. Similarly, Roy et al¹⁵ found that asthma hospitalization rates were significantly higher in rural vs urban Mississippi. Rural children are less likely to have pediatric health care services, particularly subspecialty services, compared with children living in urban or suburban regions due to proximity to tertiary care centers.¹⁶ Previous investigations have noted that negative asthma outcomes and un-

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deruse of controller medications are associated with lack of specialty asthma care.^{16,17} Increased morbidity and decreased access to appropriate care are significant concerns in medically underserved communities, such as the Delta region, one of the most medically underserved, impoverished US regions.^{18,19} We examined asthma morbidity, aeroallergen exposure and sensitization, medication use, health care use, and barriers among asthmatic children in Arkansas' Delta region. The aims of the study were to establish clinically relevant associations that might place these children at risk for poor health-related outcomes and to provide a framework for future targeted interventions in this high-risk rural population.^{13,14}

Methods

Study population

Participants were children 4 to 17 years of age with current asthma who were enrolled in Dumas, Lakeside, and Marvell public schools in Arkansas' Delta region. These districts are located in counties where 40% or more of families with children live below the poverty level.²⁰ During enrollment (2006–2009), students were predominately African American: Dumas, 1,034 of 1,552 (67%); Lakeside, 989 of 1,288 (77%); and Marvell, 507 of 564 (90%). In addition, 78% or more of students met federal free or reduced lunch guidelines.²¹ All students in participating schools received written information about the research study, and caregivers of potentially eligible participants were asked to contact study personnel if they had interest in participating. Other recruiting measures included informational meetings at school or community venues. All enrolled children met the minimum criteria for asthma according to National Asthma Education and Prevention Program (NAEPP) guidelines.²² All study procedures were approved by the University of Arkansas Medical Sciences' institutional review board, and all participants gave written informed consent or assent.

Study procedures

We conducted a cross-sectional investigation using an interview format, skin prick testing (SPT), and home inspection. The caregiver primarily responsible for the child's health care was interviewed. All questions were administered to the caregiver by trained interviewers in a structured, face-to-face interview. Sociodemographic variables; frequency of daytime, nocturnal, and exercised-induced asthma symptoms during the preceding 4 weeks; asthma medication use; health care access and use; and school absenteeism were reported.

Body mass index (BMI) measurement and SPT were conducted. Using a MultiTest II device (Lincoln Diagnostics, Decatur, Illinois) and standard SPT techniques,²³ we determined allergen sensitization for dust mites, cat, dog, mouse, cockroach, ragweed, Bermuda grass, Bahia grass, oak tree, *Aspergillus fumigatus*, and *Alternaria alternata*. Wheal reactions were measured after 15 minutes. The SPT result was considered positive if the wheal was 3 mm or greater than that of the negative control.

Health insurance, health care use, and access

All sources of medical insurance and copayment requirements for each child were obtained. Caregivers were asked about their child's regularly scheduled physician's visits, acute care visits, emergency department (ED) visits, and hospitalizations for asthma. Caregivers reported payment barriers, transportation barriers to health care visits, and travel time to the primary care provider (PCP) and nearest ED.

Health attitudes and beliefs

Caregivers were asked how frequently they thought their child needed to be seen for regular asthma checkups and how important

it was for their child to be seen by the physician for asthma even when no symptoms were present. Responses to the importance of regular medical care for asthma were very important, important, somewhat important, not at all important, or unsure.

Aeroallergen assessment

Bedroom dust samples were collected using a handheld vacuum (Hoover model C2094; TTI Floor Care North America, Glenwillow, Ohio) and Mitest dust collection kit (Indoor Biotechnologies, Charlottesville, Virginia) from the child's bedroom according to published methods.^{24,25} Dust was analyzed for allergen content by 2-site monoclonal-based enzyme-linked immunosorbent assay for Bla g 1, Bla g 2, Der p 1, Der f 1, Can f 1, Fel d 1, and Mus m 1 allergens.²⁵ Bla g concentrations were reported in units per gram of dust; all other allergens were reported in micrograms per gram of dust.

Medication use

Medications were categorized as controller or rescue medications. Asthma controllers included inhaled corticosteroids (ICSs), combination ICSs and long-acting β_2 -agonists, and leukotriene receptor antagonists (LTRAs). Rescue medications included short-acting β_2 -agonists and anticholinergic medications. Caregivers reported all prescribed medications and how often each was taken in the past 4 weeks. If the caregiver could not recall the medication name, dose, or frequency, a follow-up telephone call was conducted to obtain that information.

Statistical analysis

Eight dichotomized variables were considered as indicators of asthma morbidity. Nocturnal awakening was categorized as 2 or fewer or more than 2 nights per month. Exercise limitations, daytime cough, and rescue medication use were categorized as fewer than 2 or 2 or more days per week. Schooldays missed, ED visits, acute care visits, and overnight hospitalization were categorized as yes or no.

Sociodemographic variables (age, sex, race, insurance type, household income, maternal education, and BMI), indicators of asthma severity (inhaled controller use, oral controller use, and atopy status), and health care access factors (problems paying for medication, physician visits, ED visits, and transportation) were considered predictors of asthma morbidity. Association between bedroom allergen exposure and morbidity outcomes and positive SPT results were also examined. Bedroom allergen exposure was examined in the context of previously established cutoffs.^{7,23,26–28} For sensitization risks, Can f 1, Fel d 1, Der p 1, and Der f 1 concentrations of 2 $\mu\text{g/g}$ or more, Mus m 1 concentrations of 1.6 $\mu\text{g/g}$ or more, and Bla g 1 or Bla g 2 concentrations of 2 U/g or more were examined. For morbidity risks, concentrations of Can f 1, Fel d 1, Mus m 1, Der p 1, and Der f 1 of 8 $\mu\text{g/g}$ or more and Bla g 1 or Bla g 2 concentrations of 8 U/g or more were examined.

Logistic regression was used to determine effects of a continuous predictor on each of the morbidity measures. The χ^2 test (or Fisher exact test for small sample sizes) was used for comparing 2 dichotomous variables. Effects were estimated using odds ratios (ORs) and 95% confidence intervals (CIs). Paired continuous variables were compared using the paired *t* test. Logistic regression was performed using *lrm* function in the RMS package, and Fisher exact test was performed using the *fisher.exact* function in Exact 2×2 package in R.²⁹ All tests were performed assuming a 2-sided significance level of .05.

Results

Of the 121 enrolled study participants (Table 1), 12 individuals were removed because of missing data. Most (83%) were African

Table 1
Demographic characteristics, BMI, and atopy status of study population^a

Characteristic	No. (%) of patients
Median age (IQR), y	9 (7–12)
Male sex	59 (54)
Race	
African American	91 (83)
White	18 (17)
Insurance type	
ARKidsFirst ^b	70 (65)
Medicaid	29 (27)
Private	8 (7)
Household income	
>\$20,000	30 (29)
≤\$20,000	72 (71)
Caregiver married	50 (43%)
Caregiver educational level	
<9th grade	3 (4)
9th to =11th grades	0 (0)
High school graduate	30 (38)
Some college	46 (58)
Median BMI (IQR)	19.80 (16.38–24.40)

Abbreviations: BMI, body mass index; IQR, interquartile range.

^aData are presented as number (percentage) of patients unless otherwise indicated. Data are missing for some participants.^bARKids First is Arkansas' State Child Health Insurance Program;

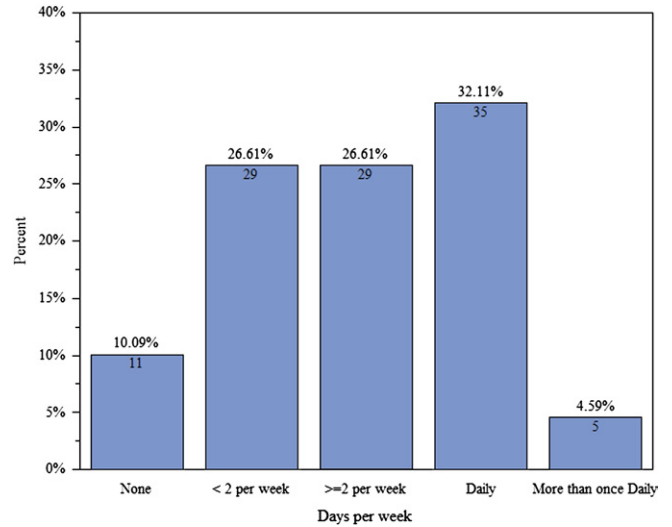
American, and 71% had an annual household income of \$20,000 or less. Most caregivers (105/109) responsible for health care and medications for the participant identified themselves as the mother or female guardian, and 50 of 109 (43%) were married. Thirty-eight percent of primary caregivers had graduated from high school, whereas 58% reported taking coursework beyond high school. Forty-two children (37%) lived in a home with 1 or more smokers. Almost all participants had state-issued medical insurance, Medicaid (27%), or Arkansas' State Child Health Insurance Program (65%). Copayment for prescription medications (21%) or health care visits (18%) was not frequently reported. The median copayment was \$5 for prescription medications and \$10 for health care visits, and less than 10% of caregivers reported having problems paying for medications or health care visits.

Most caregivers (95%) identified a PCP or main clinic for their child's routine asthma care (Table 2), and most participants listed a physician or nurse practitioner as their child's main health care provider (family practitioner, 60%; pediatrician, 12%; nurse practitioner, 11%; and other health clinic or multispecialty group, 17%). Health care use was high, with 54% of children having 4 or more regularly scheduled asthma visits in the past year, 43% having an unscheduled acute care visit in the 3 months preceding study enrollment, and 28% reporting 1 or more ED visit for asthma in the preceding 6 months. Of those with an identified PCP or clinic, 20%

Table 2
Health care use factors

Factor	No. (%) of patients ^a (N = 109)
Identified a PCP or clinic for regular asthma care	104 (95)
Unscheduled (acute) asthma visit in past 3 months	47 (43)
ED visit in the past 6 months	30 (28)
Overnight hospitalization	5 (5)
No. of actual visits for regular (nonacute) asthma care in the past year ^b	3.41 (3.76) ^c
No. of visits per year caregiver thought appropriate for regular (nonacute) asthma care ^b	6.63 (6.14) ^c

Abbreviations: ED, emergency department; PCP, primary care provider.

^aData are presented as number (percentage) of patients unless otherwise indicated.^bPaired *t* test *P* < .001.^cMean (SD) of 102 participants.**Fig. 1.** Rescue medication use in the past 6 months. Rescue medications included short-acting β_2 -agonist and anticholinergic medications (N = 109).

had difficulty paying for transportation and 82% reported travel time of less than 30 minutes. There were 4 participants who reported travel time to the PCP or clinic as greater than 1 hour; all 4 had 1 or more ED visits in the previous 6 months. Most caregivers (80%) stated that it was "very important" for their child to see the physician for regular asthma checkups. However, the mean number of visits per year reported as appropriate for scheduled (non-acute) asthma care per the caregivers' judgment (6.1) was significantly higher than the actual mean number (3.4) of visits reported by caregivers (*P* < .001) for the year before enrollment.

Caregivers' report of daytime and exercise-induced symptoms during the preceding 4 weeks revealed that most participants had frequent, uncontrolled symptoms. Most (54%) reported daytime cough, wheeze, chest tightness, or trouble breathing on 2 or more days per week or daily. Nocturnal symptoms were also poorly controlled, with 61% reporting nocturnal awakenings more than 2

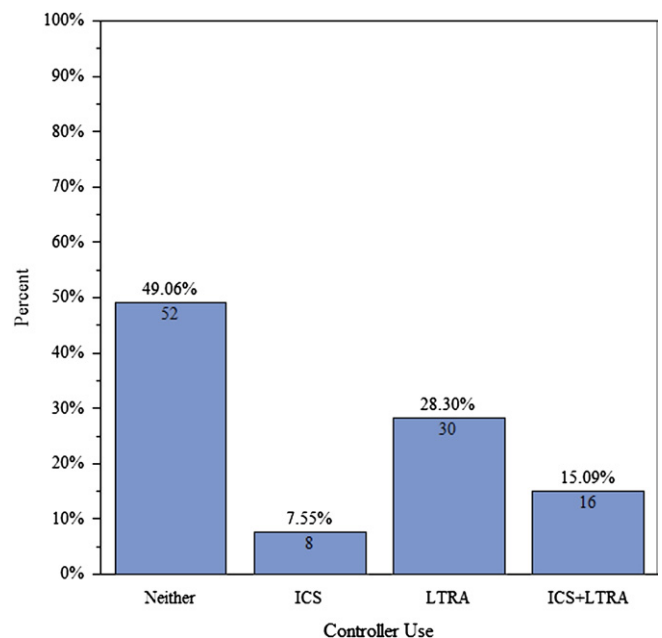
**Fig. 2.** Current asthma controller use in the past 6 months. ICS indicates inhaled corticosteroids and combination inhaled corticosteroids and long-acting β_2 -agonists. LTRA indicates leukotriene receptor antagonists (N = 106).

Table 3
Percentage of positive skin prick test results

Allergen	No. (%) of sensitized patients (N = 91 ^a)
Cockroach	13 (14)
Cat	8 (9)
Dog	4 (4)
Dust mite	24 (27)
Mouse	13 (15)
Mold	16 (18)
Pollen (grass, tree, or weed)	45 (51)
Atopic (any positive)	58 (64)

^aData missing for some participants.

nights per month. Similarly, 51% reported exercise limitations on 2 or more days per week. Seventy percent reported missing 2 or more schooldays due to asthma during the preceding school year.

Only 10% of caregivers stated that their child had not used a rescue medication in the 6 months before enrollment (Fig 1); however, 27% reported use of rescue medications on 2 or more days per week, 32% reported daily use, and 5% reported use more than once daily (excluding preexercise use). Forty-nine percent reported that their child did not take an asthma controller; 8% were taking daily ICSs, 28% were taking LTRAs, and 15% were taking both ICSs (with or without long-acting β_2 -agonists) and LTRAs (Fig 2).

Overall, most participants (64%) were atopic, having 1 or more positive SPT results (Table 3). Bedroom allergen exposure (Table 4) was prevalent, with detectable bedroom concentrations of Der p 1 (88%), Can f 1 (67%), Fel d 1 (47%), Mus m 1 (97%), Bla g 1 (44%), and Bla g 2 (29%). An association was found between sensitization and exposure for Der p 1, Can f 1, Mus m 1, and Bla g 2 (Table 5). Concentrations above previously established asthma symptom cutoffs were not prevalent, with less than 15% of homes having levels above the cutoffs (Table 4). Participants with Can f 1 concentrations of 8 μ g/g or higher were more likely to report exercise limitations ($P = .02$).

Children taking LTRAs reported more missed schooldays (OR, 3.25; 95% CI, 1.17–8.99), and those taking inhaled controllers reported more exercise limitations (OR, 5.52; 95% CI, 1.88–16.28), daytime symptoms (OR, 2.68; 95% CI, 1.004–7.14), and rescue medication use (OR, 4.96; 95% CI, 1.37–18.0). A total household income of \$20,000 or less was associated with increased rescue medication use (OR, 2.60; 95% CI, 1.08–6.23). A marginal association was found between higher caregiver educational level (some college) and decreased rescue medication use (OR, 0.59; 95% CI, 0.34–1.02). Tobacco exposure, problems paying for medications or health care visits, transportation problems, and BMI (normal median BMI) were not significantly associated with increased morbidity.

Discussion

In the current study, we characterize predominantly minority asthmatic children living in a rural, impoverished region, a popula-

Table 5
ORs (95% CIs) (Fisher Exact Test) showing association between bedroom allergen concentration and skin prick test result

Bedroom allergen concentration	Association with positive skin prick test result, OR (95% CI)	P value
Der p 1 ≥ 2 μ g/g	4.27 (1.26–14.7)	.03
Der f 1 ≥ 2 μ g/g	0.73 (0.19–2.54)	.76
Der p/f ≥ 2 μ g/g	1.88 (0.62–5.56)	.29
Can f 1 ≥ 2 μ g/g	16.06 (1.15–506)	.04
Fel d 1 ≥ 2 μ g/g	1.35 (0.053–11.7)	.58
Mus m 1 ≥ 1.6 μ g/g	4.28 (1.07–17.2)	.04
Bla g 1 ≥ 2 U/g	1.74 (0.35–7.39)	.43
Bla g 2 ≥ 2 U/g	4.63 (1.13–20.2)	.02

Abbreviations: CI, confidence interval; OR, odds ratio.

tion that has not been adequately studied. We examined demographic, caregiver, and environmental factors and their association with asthma morbidity. We found evidence of poorly controlled asthma, inadequate ICS use, high health care use, and high prevalence of atopy. Adverse asthma outcomes disproportionately affect children in minority and low-income populations regardless of location. We and others have found significant morbidity in US populations outside the inner city.^{1,13,14,30} Despite these findings, large-scale initiatives to address rural asthma morbidity have not been established. In fact, public health strategies have failed to adequately address a multitude of health conditions for rural Americans,^{31,32} and it is unlikely that population-based interventions designed for urban or suburban children will address the needs of children living in rural environments due to their unique challenges. To better understand factors associated with asthma morbidity and in our efforts to plan future interventions tailored to the specific needs of high-risk rural children with asthma, we conducted a cross-sectional examination of children living in the Arkansas Delta region.

Standards of asthma care have not translated to children living in the Delta region, one of the most impoverished, rural US regions. Even though most children reported uncontrolled symptoms, we found that only 23% were taking daily ICSs, whereas 28% were taking LTRAs as monotherapy. According to the NAEPP guidelines,²² LTRAs are not preferred monotherapy for persistent pediatric asthma. Wilson et al³³ reported increased claims for LTRAs among nonurban compared with urban Ohio children. This finding, along with the high rate of LTRA use in our population, suggests that prescribing patterns among rural health care professionals may differ from urban health care professionals. Another possible explanation may be that some caregivers selectively fill prescriptions for LTRAs compared with inhaled asthma controller medications.

Children taking controllers were more likely to report negative outcomes perhaps because children with the most severe disease were prescribed controller medications; however, the frequency of

Table 4
Bedroom allergen distribution

Allergen	Range	Median	No. (%) of patients (N = 94)		
			No. (%) above limits of detection ^a	No. (%) above sensitization cutoff ^b	No. (%) above morbidity cutoff ^c
Der p + f, μ g/g	BD–36.47	1.00	83 (88)	32 (34)	13 (14)
Can f 1, μ g/g	BD–81.62	0.07	63 (67)	13 (14)	7 (7)
Fel d 1, μ g/g	BD–694.06	BD	44 (47)	11 (12)	8 (9)
Mus m 1, μ g/g	BD–94.84	0.29	91 (97)	21 (22)	10 (11)
Bla g 1, U/g	BD–41.40	BD	41 (44)	15 (16)	2 (2)
Bla g 2, U/g	BD–138	BD	27 (29)	19 (20)	10 (11)

Abbreviation: BD, below detection.

^aLimits of detection of the assay were 0.02 μ g/g for Der p 1, Der f 1, Can f 1, and Fel d 1, 0.01 μ g/g for Mus m 1, 0.4 U/g for Bla g 1, and 1 U/g for Bla g 2.^bSensitization cutoffs were 2 μ g/g or greater for Can f 1, Fel d 1, Der p 1, and Der f 1, 1.6 μ g/g or more for Mus m 1, and 2 U/g or more for Bla g 1 and Bla g 2.^cMorbidity cutoffs were 8 μ g/g or more for Can f 1, Fel d 1, Mus m 1, Der p 1, and Der f 1 and 8 U/g or more for Bla g 1 and Bla g 2.

uncontrolled symptoms suggests undertreatment or nonadherence to prescribed medications. Findings of low ICS use have been reported in other high-risk populations.^{34–36} Finkelstein et al³⁷ found that 73% of 1,083 Medicaid-insured children were underusers of asthma controllers, and lower maternal educational level and minority race were associated with ICS underuse. Disparities in referral and access to asthma subspecialty care among publicly insured vs privately insured children have been well described and likely play a role in ICS underuse in the study population.^{4,35,38} Having a PCP, having written asthma action plans, and seeing an asthma specialist are factors related to increased ICS use. Farber et al³⁹ reported that caregivers who did not understand the role of ICSs as a preventive medication were less likely to adhere to daily dosing. Other investigators have reported that compared with white children, minority children were less likely to have written asthma action plans,⁴⁰ preventive medications,⁴¹ and an asthma specialist.⁴ Furthermore, minority parents are more likely to have safety concerns related to asthma medications.¹² These findings reflect the complexity of implementing guidelines-based care in high-risk populations.

Our findings demonstrate that poorly controlled asthma is not an exclusively inner-city problem, and there are similarities between rural and urban minority children with asthma^{2,3,42} however, we discovered unique dissimilarities, particularly in terms of caregiver characteristics. Most caregivers (96%) reported completing high school and/or taking some college coursework. This is significantly higher than reported in inner-city populations.^{7,8,43} This is an important finding because higher caregiver educational level has been associated with decreased rescue medication use³⁷ and increased controller medication use.³⁹ Marital status of the caregiver was another difference, with 48% of caregivers reporting that they were married. Reported married status is higher than reported in other minority populations³; however, we did not find any differences in morbidity between children of married or unmarried caregivers.

In addition to differences in caregiver characteristics, there are significant barriers compounded by the rural locale and the fact that rural regions are more likely to be medically underserved.¹⁶ Reports on health outcomes in the Delta are overwhelmingly negative.^{18,19} Virtually all participants (98%) had medical insurance and a PCP, suggesting that other factors affect rates of poorly controlled asthma. One potential impediment to care is transportation. Although 82% of caregivers reported that their child's PCP was less than 30 minutes away by car, paying for transportation to scheduled medical visits was problematic for 20% of caregivers, and all 4 participants with a more than 1-hour drive by car had a recent ED visit. This suggests that lack of reliable transportation may affect access to care as previously reported^{12,31} and may be more problematic in areas, such as the Delta, where public transportation is uncommon. In addition to transportation problems, pediatric specialty and subspecialty care is lacking,⁴⁴ the involvement of which have been related to improved asthma outcomes.³⁷ Better outcomes have also been reported with home-based interventions^{43,45}; however, sparse population density and few community resources in rural areas pose significant barriers to implementation of home-based programs.

The prevalence of atopy was high and similar to rates reported in other minority populations.^{23,46} Others have reported decreased rates of atopy among rural children, suggesting rural environments may be protective⁴⁷; however, we and others⁴⁸ demonstrate that not all rural environments are protective. Although some rural environments confer protection against atopy, other factors, such as sociodemographic characteristics, diet, tobacco smoke exposure, childhood infections, and pollution, are important determinants.^{49–51} The relationships among allergen sensitization, asthma, and concentration and timing of

allergen exposure are key issues that need further exploration in this population.

Previous studies have linked sensitization and aeroallergen exposure to increased morbidity.^{3,7–9,27} We found associations between bedroom exposure and sensitization for dust mite, dog, cockroach, and mouse allergens. Cockroach and mouse allergens have been recognized as relevant allergens in inner-city and suburban environments.^{3,7,8,26,27} To our knowledge, this is the first report linking exposure to these allergens to sensitization in a rural, low-income population. We did not find a relationship between aeroallergen concentrations and morbidity except for exercise limitations with high dog allergen concentrations. Correlations between aeroallergen concentrations and symptoms may not have been found because there were very few homes with high allergen concentrations, and a high prevalence of uncontrolled symptoms makes it more difficult to associate morbidity with allergen exposure. Another plausible explanation could be that only bedroom exposure was examined, and overall household allergen burden may be important in determining morbidity.

One study limitation is the study population size. Counties of participating school districts have population densities averaging 27 persons per square mile. By comparison, large urban regions have population densities up to more than 9,000 persons per square mile.²⁰ Lower population densities make investigation of large numbers of children difficult due to time, transportation, and cost restraints. Another limitation was the cutoff of less than 2 days or 2 or more days per week for daytime symptoms and rescue medication use. The NAEPP guidelines²² categorize uncontrolled symptoms as more than 2 days per week; therefore, the 2 or more days per week categorization includes some individuals who fall within the controlled classification. Despite this limitation, assuming that all participants reporting symptoms of 2 or more days per week had controlled symptoms, our data still reveal a large proportion of children with daily symptoms, high acute care use rates, and increased rescue medication use. Another study limitation is potential caregiver recall bias. Caregiver responses were not confirmed by pharmacy or insurance claims; therefore, there may have been potential underreporting or overreporting of symptoms, medication use, or health care use. To decrease recall bias, we asked caregivers to provide information during a short period (4 weeks) and verified medications by having the interviewer or caregiver read the prescription labels of all prescribed medications.

We report important and novel findings of poorly controlled asthma, unique caregiver characteristics, aeroallergen exposure, and allergic sensitization among predominantly minority and low-income, rural children. We provide evidence that guidelines-based asthma care has not translated to the rural community despite the fact that the population is highly insured, relatively educated, and reported few payment problems. There are a number of nonmodifiable risk factors, such as geographic location and household income; however, some risk factors, such as implementation of guidelines-based ICS use and reduction in transportation barriers, are potentially modifiable. Public health initiatives to improve rural asthma outcomes should focus on dissemination and implementation of asthma guidelines to rural health care professionals and community stakeholders. These initiatives can be performed through school-based clinics, mobile clinics, and community health programs for health care professionals and parents. To decrease the effect of physical barriers related to geographic location, transportation problems, and lack of pediatric specialty care, new and innovative technologies, such as telemedicine, telephone, texting, and web-based programs, should be considered feasible and cost-effective adjuncts to current health care services.

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