

The Relationship Between School Absence, Academic Performance, and Asthma Status

SHENIZ MOONIE, PhD^a
DAVID A. STERLING, PhD, CIH^b
LARRY W. FIGGS, PhD, MPH^c
MARIO CASTRO, MD, MPH^d

ABSTRACT

BACKGROUND: Children with asthma experience more absenteeism from school compared with their nonasthma peers. Excessive absenteeism is related to lower student grades, psychological, social, and educational adjustment. Less is known about the relationship between the presence of asthma and the academic achievement in school-aged children. Since students with asthma miss more days from school, this may negatively impact their academic achievement. The goal of this study was to investigate the relationships between absenteeism, presence of asthma, and asthma severity level with standardized test level performance in a predominantly African American urban school district.

METHODS: A cross-sectional analysis was conducted of 3812 students (aged 8-17 years) who took the Missouri Assessment Program (MAP) standardized test during the 2002-2003 academic year.

RESULTS: After adjustment for covariates, a significant inverse relationship was found between absenteeism and test level performance on the MAP standardized test in all children ($F = 203.9, p < .001$). There was no overall difference in test level achievement between those with and without asthma ($p = .12$). Though not statistically different, those with persistent asthma showed a modestly increased likelihood of scoring below Nearing Proficient compared with those with mild intermittent asthma (adjusted odds ratio = 1.93, 95% confidence intervals = 0.93-4.01, $p = .08$).

CONCLUSIONS: A negative impact of absenteeism on standardized test level achievement was demonstrated in children from an urban African American school district. Children with asthma perform the same academically as their nonasthma peers. However, those with persistent asthma show a trend of performing worse on MAP standardized test scores and have more absence days compared with other students. More research is warranted on the effects of persistent asthma on academic achievement.

Keywords: asthma; severity; academic; test level performance; school.

Citation: Moonie S, Sterling DA, Figgs LW, Castro M. The relationship between school absence, academic performance, and asthma status. *J Sch Health*. 2008; 78: 140-148.

^aAssistant Professor, (sheniz.moonie@unlv.edu), Department of Environmental and Occupational Health, Division of Epidemiology and Biostatistics, University of Nevada, Las Vegas, School of Public Health, 4505 Maryland Parkway Box 453064, Las Vegas, NV 89154-3064.

^bAssociate Professor, (sterling@slu.edu), Division of Environmental and Occupational Health, St Louis University, School of Public Health, 3545 Lafayette Avenue, St. Louis, MO 63104.

^cAssociate Professor, (larry.figgs@uky.edu), Department of Preventive Medicine & Environmental Health, College of Public Health, University of Kentucky, 121 Washington Ave, Lexington, KY 40532-0003.

^dAssociate Professor of Medicine and Pediatrics, (castrom@im.wustl.edu), Division of Pulmonary and Critical Care Medicine, Department of Internal Medicine and Pediatrics, Washington University School of Medicine, 660 S Euclid Ave, St Louis, MO 63110-1093.

Address correspondence to: Sheniz Moonie, Assistant Professor, (sheniz.moonie@unlv.edu), Department of Environmental and Occupational Health, Division of Epidemiology and Biostatistics, University of Nevada, Las Vegas, School of Public Health, 4505 Maryland Parkway Box 453064, Las Vegas, NV 89154-3064.

Increased absenteeism, minority status, gender, and low socioeconomic status (SES) are all measures associated with poor academic performance among the school-going child.¹⁻¹⁰ Studies demonstrate that children with asthma are absent more often compared with students without asthma,^{1,4,11-17} particularly those with persistent asthma.^{4,18,19} School absences due to asthma are usually brief, but this pattern of absence has been shown to be more harmful academically.²⁰

Previous studies have sought to determine if children with asthma perform academically different in school compared with well children using both standardized test scores and grade point averages as achievement measures.^{1,13,14} However, these few studies have inconsistent findings concerning if the presence of asthma truly puts a child at risk of performing academically different compared with students without asthma. There is some evidence suggesting that students with asthma perform just as well as their school peers without asthma^{1,14} using both standardized test scores and grade point averages as achievement outcomes. However, these studies targeted white middle class populations residing in suburban locations. Other studies have shown that children with asthma are at an increased risk of learning disability, grade failure, and performing lower on standardized tests compared with well children.^{12,13,16,21} Children with asthma may be at risk for decreased school functioning due to a combination of factors including acute respiratory exacerbations, increased absenteeism, poor medical management of disease, side effects of oral steroids, and the psychological stress associated with a chronic illness.²² Since asthma prevalence is highest among minority students living in urban areas,²³⁻²⁷ it is crucial to understand the impact of this common disease on their educational performance.

It is of interest to determine if children with asthma perform differently on standardized tests compared with their peers without asthma. We sought to determine if (1) absenteeism is associated with academic test level performance; (2) students with asthma are at increased risk of poor standardized test level achievement compared with those without asthma; and (3) there is a relationship between asthma severity level and academic test level performance in a predominantly African American school district.

METHODS

Absenteeism, demographics, and academic achievement measures were obtained from a predominantly African American Missouri school district located in the greater St Louis Metropolitan region for the 2002-2003 school year.²⁸ Asthma status and severity were assigned by the nurse at each school. Asthma

symptom severity was determined based on the child/caregivers response to standardized questions from the National Asthma Education and Prevention Program²⁹ and previously published by our group.³⁰ For the purpose of this study, asthma severity was based exclusively on symptomology and not modified by the use of medications. Asthma symptom severity was assessed during the first 2 months of school through a form provided by the nurse to all participating students with asthma in grades 5-12 to complete while at school. It was determined by the nurses that children in grades K-4 would have a difficult time completing the form themselves, and the forms were sent home for completion with the parent or caregiver. The Asthma Symptomology form contains questions regarding the frequency of asthma symptoms such as shortness of breath, cough, wheeze, and sleep disturbances in the previous month (Figure 1). The asthma symptom severity for these students was determined using the response to these questions as mild intermittent, mild, moderate, or severe persistent asthma. All components of the study were approved by the St Louis University Institutional Review Board, the School District administration and school board, and met all Family Educational Rights and Privacy Act (U.S. Federal Law 20 U.S.C § 1232g; 34 CFR Part 99) regulations.³¹ Participation was strictly voluntary and incentives were not offered to the parents or the students.³²

Study Design

Asthma Status Ascertainment. The nurse for each school identified students as having asthma throughout the school year in 1 of the following ways: reported by a parent/guardian to the nurse indicating that the student has asthma; asthma medications (eg, albuterol) were supplied to the school nurse for administration or student self-administration with a physician's order; or a physician signed asthma action plan was submitted. The subtotals of the students identified as having asthma by each of the above-mentioned methods were not provided by the school nurses. A clinical evaluation for asthma was not performed. All students not meeting the above criteria were considered as not having asthma. Asthma assessment using school health records and school nurse evaluation have both been shown to be efficient methods of tracking disease.^{33,34}

Study Population. A cross-sectional analysis was performed of all students in grades 3, 4, 7, 8, 10, and 11 registered in the school district that took the Missouri Assessment Program (MAP) standardized test during the 2002-2003 academic year. MAP test achievement level information was available for 3877 (100%) of the students in the district database. Forty-seven (1%) of the students did not receive a test score due to an incomplete exam and were excluded from

Figure 1. Asthma Symptom Severity Questionnaire

Controlling Asthma in Schools

Nurse Completed Asthma Symptomology Form

Name of School _____ Child's ID: _____ Date Completed: _____

1. How often have you had a cough, wheeze, shortness of breath, or chest tightness during the past 30 days?	<input type="checkbox"/> 2 or less times per week	<input type="checkbox"/> 3-6 times per week	<input type="checkbox"/> daily	<input type="checkbox"/> more than once per day
2. How often have you woken up from sleep because of coughing, wheezing, shortness of breath, or chest tightness in the past 30 days?	<input type="checkbox"/> 2 or less times per month	<input type="checkbox"/> 3-4 times per month	<input type="checkbox"/> 5-9 times per month	<input type="checkbox"/> 10 or more times per month
3. In the past 30 days, how often have you had cough, wheeze, shortness of breath, or chest tightness while exercising or playing?	<input type="checkbox"/> 2 or less times per month	<input type="checkbox"/> 3-4 times per month	<input type="checkbox"/> 5-9 times per month	<input type="checkbox"/> 10 or more times per month
Peak Flow % Normal	<input type="checkbox"/> > 80%	<input type="checkbox"/> > 80%	<input type="checkbox"/> 60%-80%	<input type="checkbox"/> < 60%
Asthma Symptomology Classification	Mild Intermittent	Mild Persistent (refer to software)	Moderate Persistent (refer to software)	Severe Persistent (refer to software)
Recommended Action	<ul style="list-style-type: none"> • Review AAP, if exists • If no/out of date AAP, request • Encourage regular doctor visits 	<ul style="list-style-type: none"> • Review AAP, if exists • If no/out of date AAP, request • Assess peak flows • Call parent if no meds at school • Review meds with Med. Director 	<ul style="list-style-type: none"> • Review AAP, if exists • If no/out of date AAP, request • Assess peak flows • Call parent if no meds at school • Review meds with Med. Director • Contact Parent • Contact PCP/fax referral form 	<ul style="list-style-type: none"> • Review AAP, if exists • If no/out of date AAP, request • Assess peak flows • Call parent if no meds at school • Review meds with Med. Director • Contact parent • Contact PCP/fax referral form • Med. Director intervention

the analysis. An additional 18 (0.5%) students who were of a different race (neither African American nor white) were excluded from the analysis due to insufficient sample size. After these exclusions, a total of 3812 students were eligible for analysis. Student demographics included gender, age, race, grade level, school days enrolled, school dates absent, MAP test subject, MAP scaled score, and eligibility for free or reduced lunch. There were 176 possible days of school attendance for the school year and the average number of days students were enrolled was 142.08 days. Eligibility for free or reduced lunch was used as a surrogate measure for SES as it categorizes those families that met 125% of the Federal Poverty Level Guidelines for 2002.³⁵ Nurse assessment based on self-reported asthma severity level was only collected and

available for 175 (44%) of the 397 students identified as having asthma.

Missouri Assessment Program. The MAP is the standardized test administered throughout Missouri schools. Four grade-specific subjects are offered and scored individually: Mathematics (grades 4, 8, and 10), Social Studies (grades 4, 8, and 11), Communication Arts (grades 3, 7, and 11), and Science (grades 3, 7, and 10). The MAP scaled score is a continuous value, which range depends on the grade level and subject, and corresponds with a test level of achievement. Achievement level is categorized into 5 groupings from lowest to highest: step 1—Below Progressing, Progressing, Nearing Proficient, Proficient and step 5—Advanced.³⁶ Since the continuous scores are not comparable between the 4 specific test subject

areas, the categorical achievement outcome is used as the measure of test performance, with testing of all subject areas combined for the entire population in the analysis.

Statistical Analysis

Analyses were conducted using SAS v.9.1 (SAS Institute, Cary, NC).³⁷ Personal identifiers were removed prior to all analyses to retain anonymity of all study participants. Univariate analysis was conducted initially to determine which covariates were significant predictors for both absenteeism and academic test level performance.³⁸ The remaining significant covariates were then used for the development of multivariate models. Since the analysis demonstrated multicollinearity between age and grade level, age was not adjusted for in the analysis.³⁸ To test the relationship between absenteeism and academic test level, multivariate linear regression analysis was performed. Box plots were generated for the number of days absent with the standardized test achievement level for each subject and grade. Absenteeism was skewed and therefore was log transformed and was normally distributed. The Pearson's chi-square test of independence was used to evaluate the relationships between (1) presence of asthma and academic test level performance and (2) asthma severity level and academic test level performance. Multivariate logistic regression was used to determine the risk of performing below Nearing Proficient in the persistent asthma group (mild, moderate, and severe persistent asthma) compared with the mild intermittent asthma group. The grouping of this outcome was checked for overall model goodness of fit.³⁹

The relationship between presence of asthma and mean adjusted days absent from school was analyzed using analysis of variance (ANOVA), procedure General Linear Model in SAS.³⁷ Identification of extreme observations and the removal of outliers (above 99th percentile for both asthma and nonasthma groups) was performed⁴⁰ using procedure UNIVARIATE along with visual detection of box plots. ANOVA was used to determine differences in mean adjusted days absent between groups of differing asthma severity level. Post hoc analysis employing the least significant difference (LSD) method was used to determine significant group differences.

RESULTS

Study Population

Among the eligible study group (N = 3812), 397 (10%) of the students had asthma and 50% were male. One hundred eighty-four students (4.5%) were Caucasian and 3628 (95%) African American. The grade level distribution was 1900 (50%) students in elementary school (grades 3 and 4), 1428 in middle school (grades 7 and 8), and 484 (13%) in high school

(grades 10 and 11). The demographic distribution of this study population was statistically equivalent to the entire school district population (N = 9014) for asthma prevalence, gender, grade level distribution, and race (p = .34).³⁰

Absenteeism and Academic Test Level Performance

For all students combined, 967 (25%) scored Below Progressing, 1196 (31%) scored Progressing, 1102 (28%) scored Nearing Proficient, 470 (12%) scored Proficient, and 95 (2%) scored Advanced. Significant univariate predictors of academic performance included SES, grade level, school attended, gender, presence of asthma, and asthma severity level and were used for adjustment in developed models. Multivariate linear regression demonstrated a strong inverse relationship between absenteeism and academic test level performance in all children after adjustment for demographic covariates (F = 203.9, p < .001).³⁸ As absenteeism increases, MAP test level achievement decreases (Figure 2). Upon stratification, this relationship remained significant for both the asthma (F = 25.9, p < .001) and the nonasthma (F = 216.5, p < .001) groups (Figure 3).

Presence of Asthma and MAP Test Level Performance

The chi-square test of independence was used to assess the relationship between the presence of asthma and the test level performance. Those with asthma performed no differently compared with well

Figure 2. Mean Absence Days and Academic Achievement Level. The X-Axis Represents Academic Achievement Level. The Y-Axis Represents Total Days Absent. The Bars Represent the Mean Days Absent (Crude/Unadjusted) and Upper 95% Confidence Intervals for Each Test Level of Achievement

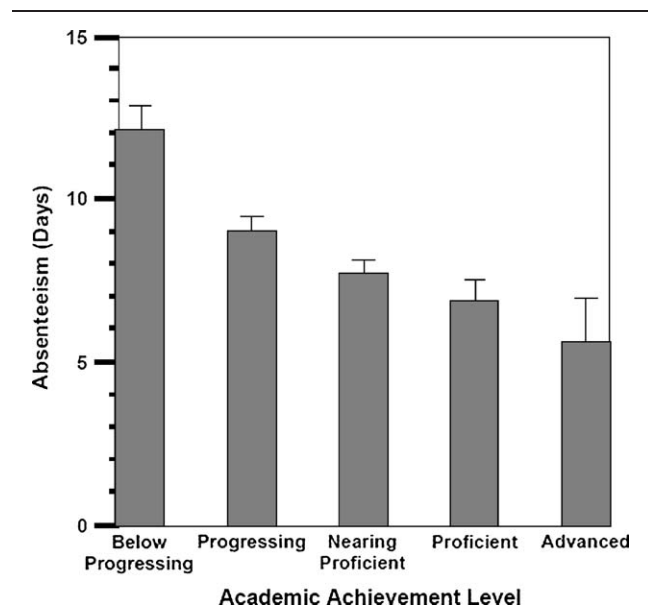
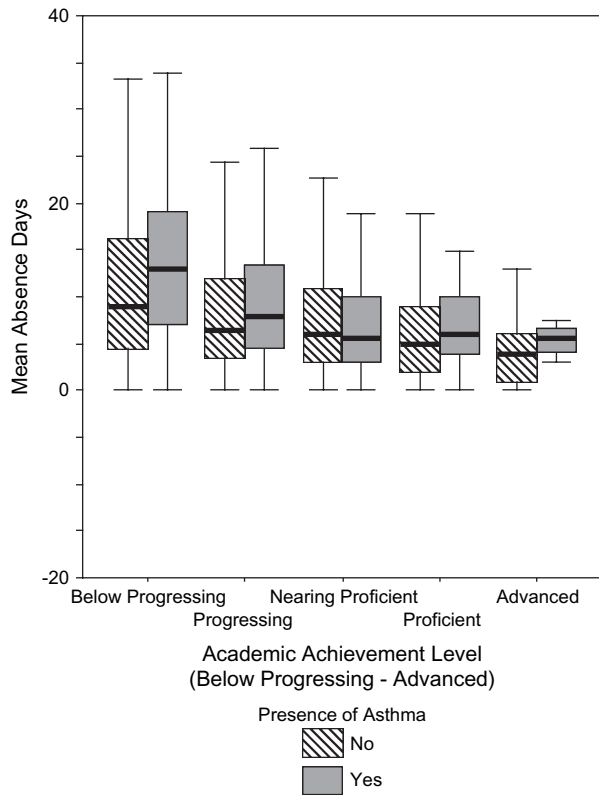


Figure 3. Achievement Level and Absenteeism by Presence of Asthma. The X-Axis Represents Academic Achievement Level. The Y-Axis Represents Total Days Absent. The Bars Represent the Mean Days Absent (Crude/Unadjusted) and Upper 95% Confidence Intervals for Each Test Level of Achievement. Arithmetic Values Are Used for Absence Days. However, Days Absent Is a Log-Normal Distribution, and the Statistical Analysis Was Performed Using the Log-Transformed Values



children ($p = .12$), even after adjustment of significant covariates (Table 1). Children with asthma also performed equivalently to well children when stratified by test subject and by grade level, and hence, these individual test scores are not presented.

Presence of Asthma and Absenteeism

Mean absent days are weighted for enrollment time. Those with asthma (10% of the students) were absent ($\bar{x} = 10.2 \pm 8.6$ days) approximately 1.5 more days compared with those without asthma ($\bar{x} = 8.9 \pm 8.8$ days) ($p = .007$). All students combined, males ($\bar{x} = 9.9 \pm 8.4$ days) were absent more than females ($\bar{x} = 8.5 \pm 8.7$ days) ($p = .0001$), and absenteeism increased by following grade level: elementary ($\bar{x} = 7.4 \pm 11.0$ days), middle ($\bar{x} = 10.8 \pm 11.8$ days), and high ($\bar{x} = 11.6 \pm 8.7$ days) ($p < .001$). Of the 403 students with asthma that took the MAP test, severity information was available for 175 (44%) of these students. Among these 175 students, 59 (34%) were assessed as having mild inter-

Table 1. Test Scores for Overall Combined Student Population and by Presence of Asthma

Test Scores	Overall, N (%) 3812 (100)	Asthma,* N (%) 397 (10)	No Asthma,* N (%) 3415 (90)
Below Progressing	964 (25)	71 (18)	893 (26)
Progressing	1191 (31)	121 (31)	1070 (31)
Nearing Proficiency	1096 (29)	129 (33)	967 (28)
Proficient	467 (12)	69 (17)	398 (12)
Advanced	94 (3)	7 (2)	87 (3)

*Fischer's exact for association between the test scores and the presence of asthma ($p = .12$).

mittent asthma, 35 (20%) mild persistent, 23 (13%) moderate persistent, and 58 (33%) severe persistent. The asthma severity breakdown among this study population was statistically equivalent when compared with the severity breakdown among those students assessed for asthma severity in the entire school district ($p = .34$).³⁰ In the analysis comparing asthma severity and school days missed, and after adjusting for demographic variables and enrollment time, mean days absent increased with increasing asthma severity level: mild intermittent ($\bar{x} = 8.5 \pm 9.5$ days), mild persistent ($\bar{x} = 11.3 \pm 9.8$ days), moderate persistent ($\bar{x} = 10.3 \pm 9.4$ days), and severe persistent ($\bar{x} = 11.6 \pm 9.4$ days) ($p = .001$). Post hoc LSD revealed a significant difference in mean days absent between the mild intermittent group with both the mild persistent ($p = .001$) and the severe persistent groups ($p = .02$). These data suggest that both the presence of asthma and the asthma severity level increase the likelihood of being absent from school.

Asthma Severity and Academic Test Performance

The asthma severity level outcome was dichotomized into 2 groups for analysis purposes: mild intermittent (59 [34%]) and persistent (116 [66%]) (mild, moderate, and severe persistent) asthma. This allowed us to test if those with persistent asthma are at greater risk of performing worse on the MAP test. The chi-square test for asthma severity demonstrated that 60% of those with persistent asthma were likely to perform below Nearing Proficient compared with 40% in the mild intermittent group ($p = .08$) (Table 2). In support of these findings, a multivariate logistic regression model showed that those with persistent asthma were 90% more likely to score below Nearing Proficient compared with those with mild intermittent asthma (adjusted OR = 1.93, 95% confidence interval = 0.93-4.01, $p = .08$). However, these findings were not statistically significant. In addition, those with persistent asthma ($\bar{x} = 12.1 \pm 9.7$ days) had higher mean days absent compared with the mild intermittent group ($\bar{x} = 7.8 \pm 9.8$ days) ($p = .001$). The highest mean absenteeism was among those with persistent asthma scoring below Nearing Proficient ($\bar{x} = 13.3 \pm 10.2$ days) (Table 2).

Table 2. Test Scores by Asthma Severity Level

Test Scores*	Mild Intermittent Asthma		Persistent Asthma [†]	
	N (%)	Days Absent, Mean (95% CI) [‡]	Test Scores	Days Absent, Mean (95% CI) [‡]
Scored Below Nearing Proficiency 97 (55)	27 (46)	10.6 (6.6-14.6)	70 (60)	13.3 (10.9-15.8)
Scored Nearing Proficiency and Above 78 (45)	32 (54)	4.9 (2.5-7.3)	46 (40)	9.6 (7.7-11.6)
Total (all scores) 175 (100)	59 (45)	7.8 (5.3-10.1)	116 (55)	12.1 (10.3-13.8)

CI, confidence intervals.

*Results are presented by 3 different test score category groupings: those who scored Below Nearing Proficiency exclusively, those scored Nearing Proficiency and Above exclusively, and those who scored in all the categories combined.

[†]Persistent asthma includes mild, moderate, and severe persistent asthma by National Asthma Education and Prevention Program criteria (28).

[‡]Rates adjusted by SES, grade level, school attended, gender, and enrollment time.

DISCUSSION

The association of asthma severity with increasing absenteeism and decreasing test level performance is an important and novel finding in our study. Previous studies involving chronically ill children found that low SES, continuous use of oral steroids, older age, behavioral problems, number of children in the family, minority race, and history of grade failure were major predictors for low school performance.^{1,9,13} After adjustment of the covariates that were available in our study (grade level, SES, and race), persistent asthma severity remained predictive of decreased test level performance. Since children with persistent asthma experience recurring episodes of absenteeism, this pattern may be contributing to decreased school performance. There is evidence suggesting that developmental problems such as school readiness skills and the need for extra help with learning among children with asthma may begin before school entry.⁴¹ It has also been reported that children with asthma are more likely to be underachievers and behind in their schoolwork despite having slightly higher scores on intelligence tests.^{42,43} Our results demonstrated that as a group, students with asthma performed equivalently to their peers without asthma in proficiency testing.

There is evidence suggesting that absenteeism plays a large role in determining students' achievement on both standardized tests and classroom performance, which this work further supports. A study conducted by Indiana State University assessed the effects of absenteeism and cognitive skills index on various achievement indicators such as Indiana State Testing Educational Program (ISTEP) scores, discrepancies, and school-based English and math tests.⁸ Contrary to our findings, they found no significant relationship overall between absences and test scores. However, they did demonstrate a negative correlation between absenteeism and achievement on certain scores including math, reading comprehension, reading vocabulary, and reading total. As the number of days absent

increased, scores decreased in all areas of the reading portion and some of the math portion for the ISTEP standardized exam. These were school-based absence counts; however, no details were given as to the appropriate weighting that makes the comparison difficult with our study. It was suggested that partial daily absences may be skewing these results in comparing the absenteeism and achievement relationship. Unlike our study, minorities were not included in the analysis and may be the group at greatest risk. Our results yielded no significant difference in test achievement by separate subject between those students with and without asthma, yet this may have occurred due to insufficient power upon stratification of subgroups.

In contrast to the Indiana experience, an examination of attendance in Louisiana public schools with larger minority presence indicated that student attendance is an important indicator of the academic success of a school.³ Schools at risk for low attendance rates were middle and secondary schools, those in metropolitan areas, and those primarily comprised of low SES students. Attendance yielded very high relationships to assessment instruments and was the strongest predictor of percent passing the Graduation Exit Exam. There were also high negative relationships between attendance and suspension, expulsion, and drop out rates. Further studies were suggested in underserved minority populations with adequate sample size to investigate the relationship between absenteeism and academic performance.

Similar to our findings, a Baltimore public elementary school with high minority representation found that student attendance was positively and significantly related to standardized achievement test performance.² Results also suggested that those schools with a larger minority enrollment would have lower math scores, but no significant differences in reading scores. Last, the school district of Philadelphia provided a study of the effect of school attendance, the use of English as a second language services, and language spoken at home on first-grade minority students (65% Hispanic).⁷

This was conducted in a school where the enrollment was 65% Hispanic. The academic performance of 101 Hispanic students was measured by reviewing standardized test scores in reading and mathematics and report card grades. Similar to our study, those students who had better median attendance scored better on their standardized tests and had higher report card grades than students below the median. Further studies are needed in underserved minority populations with adequate sample size to investigate the relationship between absenteeism and academic performance.

The association between presence of asthma, absenteeism, and academic performance among minorities is not well documented in the literature. The National Maternal and Infant Health Survey demonstrated that after adjusting for covariates, children with asthma were at 1.7 times greater risk for a learning disability.¹² Among those of low SES, children with asthma had twice the risk of grade failure compared with their well classmates. Another study in North Carolina was conducted in which families of 270 children with chronic health conditions in 11 clinics were sent surveys to determine (1) the association between academic performance and absenteeism and (2) the relationship between demographic variables and achievement and absence.¹³ Mean absent days among students with asthma were 16 compared with the state average of less than 7. Mean national achievement test scores were significantly worse in children with asthma when compared with their peers without asthma. Contrary to our findings, they demonstrated that achievement scores were related to SES but unrelated to school absence.

Given that children with persistent asthma appear to perform worse on proficiency testing, intervention strategies are needed to correct this deficiency. The American College of Allergists reported that school performance among a significant proportion of children with asthma is affected adversely by the schools approach to their medical condition.²⁰ The Centers for Disease Control and Prevention has now identified strategies for schools and districts to manage asthma within a coordinated school health program.⁴⁴ Our results demonstrated that merely the condition of asthma is not an indicator of poor performance, but rather those students with persistent asthma symptoms are at a greater risk of scoring lower than their peers without asthma. Data from this study have helped in the design of a school-based program (*Asthma 411 Initiative*) to target high- or at-risk students with asthma and to provide strategies to improve the existing health and administrative structures present in schools.^{45,46}

Our results indicate that children with persistent asthma symptoms may be the necessary target of interventions to reduce absenteeism and improve school performance. A recent randomized controlled trial of 14 elementary schools in low-income neighborhoods in Detroit assessed the impact of a comprehensive

school-based intervention on symptoms, grades, and school absences in children with asthma.⁴⁷ Parents completed phone interviews and schools provided data at baseline and 24 months postintervention. Treatment children had higher grades for science but not reading, math, or physical education. Parents of the treatment group children reported 34% fewer absences attributable to asthma in the previous 3 months. Other programs target clinicians to appropriately medicate children with asthma according to national guidelines for asthma severity and assuring that these children have an asthma action plan for the school.^{19,29,48} Our data and others⁴⁹ help identify those children with asthma who are at high risk for absenteeism and academic performance, so that more targeted interventions can be implemented in homes and schools.⁴⁹

We recognize that there are limitations to the data analysis, which we had available for the current study. Standardized test scores, using the MAP, were the only measure of academic achievement in our schools. Grade point averages, though not the best measure of academic performance, were not available for comparison within this school district. In addition, we were restricted to the school nurse's classification of the presences of asthma and severity, as no clinical confirmation was performed. However, studies have shown that identification of children with asthma by the school nurse and school-based asthma testing is an effective method for tracking disease.^{33,34} Last, asthma severity information was available for only a subset of students with asthma, mainly due to the time restrictions for nurses to call students in and conduct the interviews concurrent with their daily duties. This may have underestimated the true effect of asthma severity on absenteeism and test performance in our study. However, the current findings are consistent with the results among the total school district student population (N = 9014).³⁰ In our previous study, we assessed the relationship between the presence of asthma and the absenteeism in the entire school district for the same academic year.³⁰ A subset of 543 students with asthma was also assessed for asthma severity and the cause of absence. Students with asthma were absent significantly more compared with those without asthma after adjustment of significant covariates. Absenteeism also increased significantly with increasing asthma severity. We are not aware of any other study to date that has evaluated the effects of persistent asthma on standardized test level achievement. Further studies are warranted assessing the effects of asthma severity on academic performance with larger populations.

Our study suggests that academic performance and absenteeism are strongly related, that students with asthma are absent more often than those without asthma, and asthma severity, which is a major determinant of absenteeism, may be a major factor contributing to decreased test score performance.

Further study is warranted to determine whether school-based asthma programs are effective in reducing absenteeism and improving test scores among children with persistent asthma. Additional studies are needed to confirm the relationships between asthma severity, absenteeism, and academic performance among larger urban diverse populations.

REFERENCES

- Gustadt LB, Gillette JW, Mrazek DA, Fukuhara JT, LaBrecque JF, Strunk R. Determinants of school performance in children with chronic asthma. *Am J Dis Child.* 1989;143:471-475.
- Lamdin DJ. Evidence of student attendance as an independent variable in education production functions. *J Educ Res.* 1996;89(3):155-162.
- Louisiana Department of Education. *An Examination of Attendance in a Louisiana School*; 1993.
- McNaughton S, Smith L, Rea H, et al. The management of childhood asthma—attendance and school performance. *NZ J Educ Stud.* 1993;28(2):155-164.
- Ohlund LS, Ericsson KB. Elementary school achievement and absence due to illness. *J Gen Psychol.* 1994;155(4):409-421.
- Skiba R, Raison J. Relationship between the use of timeout and academic achievement. *Except Child.* 1990;57(1):36-46.
- Solomon A. *A Study of the Factors Which Contribute to the Academic Performance of First Grade At-Risk Hispanic Students at a Schoolwide Projects Facility.* Chicago, Ill: American Educational Research Association; 1991.
- Davis HS. *Effects of Absence and Cognitive Skills Index on Various Achievement Indicators.* Terre Haute, Ind: School of Education, Indiana State University; 1998.
- Caldas SJ. Reexamination of input and process factor effects on public school achievement. *J Educ Res.* 1993;86(4):206-214.
- Colegrove RW, Huntzinger RM. Academic, behavioral, and social adaptation of boys with hemophilia/HIV disease. *J Pediatr Psychol.* 1994;19(4):457-473.
- Doull IJ, Williams AA, Freezer NJ, Holgate ST. Descriptive study of cough, wheeze and school absence in childhood. *Thorax.* 1996;51(6):630-631.
- Fowler M, Davenport M, Garg R. School functioning of U.S. children with asthma. *Pediatrics.* 1992;90:939-944.
- Fowler M, Johnson M, Atkinson S. School achievement and absence in children with chronic health conditions. *J Pediatr.* 1985;106:683-687.
- Silverstein MD, Mair JE, Katusic SK, Wollan PC, O'Connell EJ, Yunginger JW. School attendance and school performance: a population-based study of children with asthma. *J Pediatr.* 2001;139:278-283.
- Parcel GS, Gilman SC, Nadar PR. A comparison of absentee rates of elementary school children with asthma and non-asthmatic schoolmates. *Pediatrics.* 1979;64:878-881.
- Freudenberg N, Feldman CH, Clark NM. The impact of bronchial asthma on school attendance and performance. *J Sch Health.* 1980;50:522-526.
- Taras H, Potts-Datema W. Childhood asthma and student performance at school. *J Sch Health.* 2005;75(8):296-312.
- Diette GB, Markson LE, Skinner EA, Nguyen TT, Algart-Bergstrom P, Wu AW. Nocturnal asthma in children affects school attendance, school performance, and parents' work attendance. *Arch Pediatr Adolesc Med.* 2000;154:923-928.
- Moonie SA, Strunk RC, Crocker S, Curtis V, Castro M. Community asthma program improves appropriate prescribing in moderate to severe asthma. *J Asthma.* 2005;42(4):1-8.
- Richards W. Allergy, asthma and school problems. *J Sch Health.* 1986;56(4):151-152.
- Ehrenberg RG, Ehrenberg RA, Rees DI, Ehrenberg EL. School district leave policies, teacher absenteeism, and student achievement. *J Hum Resour.* 1989;26(1):72-105.
- Celano MP, Geller RJ. Learning, school performance, and children with asthma: how much at risk? *J Learn Disabil.* 1993;26(1):23-32.
- Bender BG. Are asthmatic children educationally handicapped? *Sch Psychol Q.* 1995;10(4):274-291.
- Halfon N, Newacheck PW. Childhood asthma and poverty: differential impact and utilizations of health services. *Pediatrics.* 1993;91:56-61.
- Rana UA, Jurgens SM, Mangione S, Elia J, Tollerud DJ. Asthma prevalence among high absentees of two Philadelphia middle schools. *Chest.* 2000;118(4):79S.
- Webber MP, Carpiniello MA, Oruwariye T, Lo Y, Burton WB, Appel DK. Burden of asthma in inner-city elementary school children. *Arch Pediatr Intern Med.* 2003;157:125-129.
- Castro M, Schechtman KB, Halstead J, Bloomberg G. Risk factors for asthma morbidity and mortality in a large metropolitan city. *J Asthma.* 2001;38:625-636.
- Missouri Department of Elementary and Secondary Education. Available at: <http://www.dese.mo.us.html>. Accessed March 2005.
- US Department of Health and Human Services. *Guidelines for the Diagnosis and Management of Asthma—Update on Selected Topics 2002.* NIH Publication No. 02-5075. Bethesda, Md: National Institutes of Health, National Heart, Lung, and Blood Institute; 2002.
- Moonie SA, Sterling DA, Figs LW, Castro M. Asthma status and severity affects missed days from school. *J Sch Health.* 2005;76(1):1-7.
- United States Department of Education. Promoting educational excellence for all Americans. Available at: <http://www.ed.gov/policy/gen/guid/fpoc/ferpa/index.html>. Accessed August 2005.
- Yen B, Schneiderman L. Ethics and the care of critically ill infants and children. *Pediatrics.* 1996;98:149-152.
- Knorr RS, Condon SK, Dwyer FM, Hoffman DF. Tracking pediatric asthma: the Massachusetts experience using school health records. *Environ Health Perspect.* 2004;112(14):1424-1427.
- Hilton AT, Millard PT, Johnson M. Finding school-age children with asthma. Paper presented at: American Thoracic Society; May 25, 2004; Orlando, Fla.
- Missouri Department of Elementary and Secondary Education, Division of Administrative and Financial Services. 2005. Available at: <http://www.dese.mo.gov/divadm/food/index.html>. Accessed May 15, 2005.
- Missouri Department of Elementary and Secondary Education, Division of School Improvement. Available at: <http://www.dese.mo.us/divimprove/assess.html>. Accessed February 5, 2005.
- SAS Institute Inc. *SAS/STAT User's Guide [computer program]. Version 9.1.* Cary, NC: SAS Institute Inc; 1999.
- Fox J. *Applied Regression Analysis, Linear Models, and Related Methods.* Thousand Oaks, Calif: Sage Publications; 1997.
- Hosmer DW, Taber S, Lemeshow S. The importance of assessing the fit of logistic regression models: a case study. *Am J Public Health.* 1991;81(12):1630-1635.
- Bowerman BL, O'Connell RT. *Outlying and Influential Observations. Linear Statistical Models—An Applied Approach.* 2nd ed. Boston, Mass: PWS-Kent; 1990:249-259.
- Halterman JS, Montes G, Aaligne CA, Kaczorowski JM, Hightower AD, Szilagyi PG. School readiness among urban children with asthma. *Ambul Pediatr.* 2001;1(4):201-205.
- Geubelle F, Duchesne-Baudouin A, Jouelud M. Medicosocial problems in children with asthma. *Acta Paediatr Belg.* 1967;21:207-216.
- Yule W, Rutter M. Educational aspects of physical disorders. In: Rutter M, Tizard J, Whitmore K, eds. *Education, Health and Behavior.* London, UK: Longman; 1970:297-308.
- Centers for Disease Control and Prevention. Addressing asthma within a coordinated school health program. Available

at: <http://www.cdc.gov/healthyyouth/healthtopics/asthma.html>. Accessed November 11, 2005.

45. Richmond C, Sterling DA, Xuang X, Wilson K, Pike E. Asthma 411—addition of a consulting physician to enhance school health. *J Sch Health*. 2006;76:333-337.
46. Centers for Disease Control and Prevention. Cooperative agreement with the Centers for Disease Control and Prevention and the U.S. Department of Health and Human Services, program announcement #03030. 2003. Available at: <http://www.cdc.gov>. Accessed March 3, 2005.
47. Clark NM, Brown R, Joseph CL, Anderson EW, Litu M, Valerio MA. Effects of a comprehensive school-based asthma program on symptoms, parent management, grades, and absenteeism. *Chest*. 2004;125:1674-1679.
48. Brown R, Bratton SL, Cabana MD, Naciroti N, Clark NM. Physician asthma education program improves outcomes for children of low-income families. *Chest*. 2004;126:369-374.
49. Jones CA, Morphew T, Clement LT, et al. A school-based case identification process for identifying inner city children with asthma. *Chest*. 2004;125:924-934.