

Brief Report: Academic Attainment in Children With Sickle Cell Disease

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Objective To examine the impact of sickle cell disease (SCD) on academic attainment; the relation between academic attainment and achievement in SCD; and determinants of attainment in SCD. **Methods** Children with SCD and demographically matched peers were compared on academic attainment. Hematocrit, illness frequency, cognitive ability, and socioeconomic status were used to model the predictors of attainment problems. **Results** Attainment problems were more frequent in children with SCD ($\geq 31\%$ vs. 14%). A significant number of children showed difficulties with only attainment or academic achievement. Cognitive ability was a strong predictor of both academic outcome measures. Illness-related school absences predicted academic attainment but not achievement. **Conclusions** Academic attainment is affected by SCD. Tests of academic achievement are meaningful predictors of functional impairments for children with SCD; however, school outcomes are best evaluated with both achievement and attainment measures.

Key words academic attainment; sickle cell disease.

Tests of academic skills (academic achievement measures) are frequently used as outcome measures to assess if a disease affects children's learning in school. There have been fewer studies designed to directly assess school outcomes for children with sickle cell disease (SCD) compared with studies of academic achievement. Data on more direct measures of school performance have been reported, but the methods for operationalizing variables and interpreting this data have not been a major focus. The distinction between achievement based on psychometric testing and other school outcome variables may be important for several reasons. Academic achievement skills are necessary for performing well in school but are not sufficient. Organization skills, vigilance in completing assignments, and social behavior can limit school success in those with age-expected abilities for academic achievement. Second, if psychometric tests are the only indicator used to determine the presence of academic problems, then it is possible that the results are partly an artifact of the method. Weak performance on standardized testing can occur in children

who perform at a higher level in the classroom relative to peers. Academic attainment measures (e.g., grade promotion, need for remedial services) may provide converging data that are at least partially independent of formal testing situations.

The most common ways that academic attainment has been measured in SCD are special education placement rates (Brown et al., 1993; Fowler et al., 1988; Nettles, 1994; Wasserman, Wilimas, Fairclough, Mulhern, & Wang, 1991), grade retention (Fowler et al., 1988; Richards & Burlew, 1997), and letter grades (Richards & Burlew, 1997; Wasserman et al., 1991). These studies have come to different conclusions on the effects of SCD. For example, rates of special education placement have varied across studies—between 13% and 63% for children with SCD—with no consensus regarding whether SCD is associated with a higher rate of these problems when compared to non-SCD samples. Several reasons may explain why studies examining classroom performance might come to different conclusions: overrecruitment of children with functional problems can occur in studies

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of a clinical population; regional differences in the identification process for educational services could account for variability; and social promotion of students could also affect the accuracy of grade retention as an outcome measure. To partially account for potential local differences in the ways that schools address learning problems, a more global indicator of academic attainment may be preferable to examining indicators in isolation (Schatz, Brown, Lambert, Hsu, & DeBaun, 2001).

The current study had three hypotheses. First, following a trend in a report by Schatz and colleagues (2001), children with SCD and with no history of stroke were predicted to show more frequent attainment problems based on a global indicator than peers. Second, based on the same work, academic achievement and attainment were predicted to yield unique information about school performance. Third, disease-related variables (anemia severity and illness frequency) were hypothesized to predict academic attainment problems.

Methods

Participants

Seventy children ($n = 70$) with SCD, ages 7 to 17 years, were selected at random from local pediatric hematology clinics; of those, 50 were successfully entered in the study. Reasons for nonparticipation were not systematically collected; however, time constraints or transportation issues for clinic visits were spontaneously mentioned by eight nonparticipants. Comparison children ($n = 36$) were recruited from the same community to match on age, gender distribution, ethnicity, and socioeconomic status (SES; see Table I). The refusal rate of the comparison children was generally similar to that of the SCD group: 36 of 45 children and their parents consented to participate as a comparison group. No participant was receiving transfusion or oral hydroxyurea therapy nor had major disorders unrelated to SCD (e.g., autism, cerebral palsy). No child with SCD had a stroke, a determination based on medical records, parent report, or annual neurological screening.

Procedure

Parents of children with SCD were offered a free brief cognitive assessment of their child as part of a routine clinic visit; written feedback regarding the results was an incentive to participate. The potential value of a baseline assessment was mentioned as part of the recruitment process to increase participation among children without academic problems. Children without SCD were recruited from the same local communities, through

Table I. Demographic Characteristics of the Children with Sickle Cell Disease (SCD; $n = 50$) and the Comparison Group ($n = 36$)

	SCD		Peers without SCD	
	$M = 11.6$	$SD = 3.0$	$M = 11.0$	$SD = 2.8$
Age (years)				
Gender (male)	50%		44%	
Ethnicity (African American)	100%		100%	
Parental education				
<12 years	34%		28%	
12 years (diploma)	44		42	
Some college	18		25	
Bachelor's degree	4		6	
Annual household income ^a				
\$10,000 < \$20,000	40%		36%	
\$20,000 < \$30,000	36		36	
\$30,000 < \$40,000	20		18	
\$40,000 < \$50,000	2		3	
\$50,000 <	2		4	

^aAnnual household income was not reported for 3 of the comparison families. For children with SCD, 37 participants had homozygous hemoglobin S (HbSS; 74%), 8 had heterozygous hemoglobin S with hemoglobin C (HbSC; 16%), and 5 had heterozygous hemoglobin S with beta thalassemia (HbS β -thal; 10%).

schools and summer day-care centers and were matched as a group to the characteristics of children with SCD. The comparison children completed the study at their school or day care center and were given five dollars for their participation. Testing of SCD participants took place at clinics; therefore, examiners were not blind to SCD status but were blind to disease severity measures, SES, and study hypotheses. Medical record review and parent interviews occurred after testing had been completed, to assess demographic, disease, and educational data. Parents of all children provided informed consent for research as approved by the University of South Carolina Independent Review Board.

Academic Attainment

Academic attainment problems were identified through parent report. Two indicators of attainment problems were used to assess this outcome measure. Parents were asked if their child was receiving any special services at school and, if so, to describe the service. Services to remediate academic delays (resource support for academic skills, summer school to remediate a skill deficit) were considered one indicator of academic attainment problems. The second indicator of attainment problems was a history of repeating a grade in school (grade retention). The primary measure of attainment problems was at least one of these two attainment problems. Parent report was verified with school records in a sample of 41 of the 50 cases with SCD. Occasional discrepancies were found in the exact nature of the services, but classification (presence

or absence of attainment problems) did not differ between parent reports versus school records.

Academic Achievement

Basic reading and mathematics achievement levels were measured with the Wide Range Achievement Test, third edition (WRAT-3); tests of single-word reading ability; and written calculations. Those with delays in basic academic achievement development were identified as individuals showing either a delay in achievement or an ability–achievement discrepancy. Those presenting delays in achievement were operationalized as having an age-based standard score (SS) in reading or mathematics below the normal range ($SS < 80$). Ability–achievement discrepancies were defined as an SS in reading or mathematics that was at least one standard deviation (15 SS points) below one’s general cognitive ability score.

Disease-Related Measures

Anemia severity/hematocrit. Hematocrit data (percentage) were recorded from laboratory data obtained at the three most recent routine annual visits, including the day of testing. Mean hematocrit from the three samples was used as a study variable.

Frequency of illness. Illness frequency was defined as the number of school days missed in the past year due to illness, per parental report. Days of school missed for nonillness reasons were recorded separately. Days spent in the hospital were also assessed via parent report and verified in hospital records. Parent report for days of hospitalization correlated highly with the number of days in the hospital, as indicated in medical records ($r = .92$), and also correlated highly with days of school absence due to illness ($r = .58$). A large number of the children had no hospitalizations in the past year, which likely lowered this correlation due to restriction of range. School records obtained for 41 of the children with SCD also showed a high correlation between parent report of total days missed and what school attendance records indicated ($r = .90$).

Other measures

Cognitive ability. Participants completed six tests of cognitive abilities selected to represent six domains from Gf-Gc cognitive theory (McGrew & Flanagan, 1998). The Gf-Gc model is a hierarchical theory that posits three levels of analysis for cognitive abilities: a general level representing general ability (similar to Spearman’s g); broad domains of cognitive ability that frequently vary within and across individuals (e.g., fluid intelligence, crystallized intelligence); and narrow (compo-

nent) abilities that make up each domain. The narrow abilities can be dissociated from one another but under most circumstances are weaker predictors of behavioral performance than the broad domains of ability. A Gf-Gc cross-battery approach was used because it allowed for selecting tests that were appropriate for a wide age range and were less culturally loaded than many other alternatives. The Gf-Gc domains assessed by a range of cognitive tests, such as those in the Wechsler scales or the Kaufman batteries, has been described (McGrew & Flanagan, 1998); the framework therefore allows for a clearer generalization of expected patterns of performance across the many measures used by psychologists.

The Visual Matching, Oral Vocabulary, Spatial Relations, and Visual Matching subtests of the Woodcock-Johnson–revised (WJ-R) tests of cognitive ability were selected to assess the Gf-Gc constructs of visual processing, crystallized ability, fluid ability, and processing speed, respectively. Category Fluency from the Delis-Kaplan Executive Functions System was used to assess long-term retrieval. Finally, Digit Span–backward was administered as a test of short-term memory. These Gf-Gc constructs have been validated in both Caucasian and ethnic minority youths, and the tests selected to assess each domain have relatively low cultural content and linguistic demands (Flanagan & McGrew, 1998; McGrew & Flanagan, 1998). Age-adjusted scores were computed for each variable ($M = 100$, $SD = 15$). The mean of the standard scores was used as a measure of general cognitive ability.¹

SES. Yearly household income and years of parental education were recorded from parent report for all children. These data were recorded categorically. Household income information was collected in brackets of \$10,000, from *less than \$10,000* to *\$50,000 or more*, to create a 6-point scale. Parental education was recorded according to mean years of education for parents in the household and categorized according to *less than high school diploma*, *high school diploma*, *some college*, *bachelor’s degree*, or *graduate degree*, to create a 5-point scale.

Statistical Methods

The rates of academic attainment problems were compared across the two study groups with a one-tailed Fisher’s exact test (Hypothesis 1). A comparison of rates for academic attainment problems versus academic achievement delays was conducted within each group via a one-tailed Fisher’s exact test with confidence intervals used to assess the rates of children having only one of these two indicators of school difficulties (Hypothesis 2).

Correlation and multiple regression analyses were used to evaluate the univariate and unique predictors of academic attainment using disease-related measures, general cognitive ability, and SES measures (Hypothesis 3).

Results

Descriptive Statistics

Of the 50 children with SCD, 22 had academic attainment problems, per parental report. This figure represents 31% of the 70 children with SCD originally selected for participation, which would be the most conservative estimate of the rate of attainment problems. For the comparison group, the rate of academic attainment problems was 14% (5 of 36). For children with SCD, the mean reading decoding score was 86.6 ($SD = 161.1$), and the mean math calculations score was 87.5 ($SD = 14.5$). For the comparison group, the mean reading decoding score was 95.8 ($SD = 11.9$), and the mean math calculations score was 98.4 ($SD = 12.8$). The mean general cognitive ability scores were 92.6 ($SD = 8.5$) for the children with SCD, 98.7 ($SD = 9.3$) for the comparison group. The mean hematocrit level was 27.4 ($SD = 4.9$; range 2.7 to 37.3). For children with SCD, the mean number of school days missed per year was 18.2 ($SD = 22.5$) and the mean number of days in the hospital per year was 3.2 ($SD = 4.9$); both of these variables were positively skewed.

Rates of Academic Attainment and Achievement Problems

Academic attainment data are shown in Table II. For Hypothesis 1, those with SCD had a higher rate of academic attainment problems than peers (Fisher's exact test, $p < .05$). Children with SCD also had more frequent instances of multiple grade repetitions compared to controls (15 versus 3 cases; two-tailed Fisher's exact test, $p < .05$). Of 15 children with SCD, 5 repeated a grade past the third grade, whereas this did not occur in any peers.

Table II. Academic Attainment Data Based on Individual and Combined Criteria

Variable	Children with sickle cell disease ($n = 50$)	Peers ($n = 36$)	Fisher's exact test (p value)
Repeated a grade	15	3	.010
Needed academic services	15	4	.032
Both repeated a grade and needed services	8	2	.124
Either repeated a grade or needed services	22	5	.039

For Hypothesis 2, the rate of academic attainment problems was compared with achievement delays on testing. There was a significant relationship between attainment problems and academic achievement delays according to a Fisher's exact test, $p < .01$ (80% with similar classification); however, 10 of 50 cases (20%) showed only one of the two types of deficits (5 with attainment problems only and 5 with achievement delays only). These discrepancies between academic achievement and attainment outcomes are at a rate statistically higher than zero (95% confidence interval = 8.5–31.5%). The comparison group showed a similar pattern for attainment and achievement. Of the 36 children, 31 (89%) showed similar classification on the two outcome measures (Fisher's exact test, $p < .05$). However, 4 of 36 children (11%) showed delays on only one of the measures (2 in each category), which differs statistically from zero (95% confidence interval = 0.3–21.9%).

Predictors of Attainment and Achievement in SCD

The relationships among disease factors and attainment problems were examined for the children with SCD. The Pearson correlation matrix among academic attainment problems, mean age-adjusted academic achievement level, disease factors, cognitive ability, and SES measures is shown in Table III. Univariate predictors of attainment problems were lower achievement scores, more school days missed due to illness, lower cognitive ability, and lower family income. Univariate predictors of achievement scores were similar, except for school days missed for illness. A simultaneous regression model was used to predict the presence or absence of attainment problems with hematocrit, days of illness, cognitive ability scores, parent education, and family income as the predictors. The overall model was statistically significant, $F(5, 44) = 4.00$, $p < .01$, $R^2 = .31$. An examination of the beta weights indicated that cognitive ability, $\beta = -.40$, $t = -2.77$, $p < .01$, and days of illness, $\beta = -.24$, $t = 2.07$, $p < .05$, were

Table III. Correlations Among Variables Tested as Determinants of Academic Attainment Problems or Academic Achievement Level Among Children with Sickle Cell Disease

Variable	1	2	3	4	5	6
Academic attainment						
Academic achievement	-.62**					
Hematocrit	.03	-.04				
Days of illness	-.28*	.08	-.29*			
Global cognitive ability	-.45**	-.67**	.30*	-.06		
Parental education	-.01	.26	-.14	-.18	.26	
Family income	-.30*	.45**	-.05	-.22	.38**	.60

* $p < .05$; ** $p < .01$.

unique predictors of attainment problems. Hematocrit, $\beta = .05$, $t = 0.33$, *ns*, parent education, $\beta = .24$, $t = 1.56$, *ns*, and income, $\beta = -.24$, $t = 1.42$, *ns*, were not unique predictors.

A parallel regression model was used to evaluate mean academic achievement scores. The overall model was significant, $F(5,44) = 11.12$, $p < .01$, $R^2 = .56$. Cognitive ability was a unique predictor of achievement scores, $\beta = 0.65$, $t = 5.64$, $p < .01$, whereas none of the other predictors were significant—that is, hematocrit, $\beta = -.18$, $t = 1.64$, *n.s.*, days of illness, $\beta = -0.77$, $t = -0.52$, *ns*, parent education, $\beta = .01$, $t = 0.84$, *ns*, and family income, $\beta = .15$, $t = 1.12$, *ns*.

Discussion

The present study examined academic attainment problems in SCD with a global indicator of attainment problems, rather than with specific indicators in isolation. There were two primary findings. First, higher rates of attainment problems were found in children with SCD relative to peers. The global indicator appeared to yield information similar to that of the specific indicators, but it is likely to be less susceptible to distortion due to local differences in school policies. Second, attainment differed somewhat from academic achievement in terms of classifying children with delays and the predictors of poorer school performance.

An explanation for the difference in attainment problems between the children with SCD and the comparison group could be that the recruiting process was biased. This problem was addressed by computing a conservative rate of attainment problems based on the entire sample with SCD identified for study participation ($n = 70$), rather than the subsample that volunteered for the study ($n = 50$). There are two additional sources of data that are also not consistent with alternative explanation. The rates of attainment problems in the comparison group were at least as high, if not higher, than the rates of these problems in the children's schools (South Carolina State Department of Education, 2003). Also, illness frequency within the SCD group related to the probability of attainment problems. This relationship strengthens the idea that SCD would lead to higher rates of attainment problems than it would for peers without a chronic health condition.

Most previous reports examining frequency of illness have examined its relationship with psychometric tests of cognitive functioning and academic skills (Brown et al., 1993; Devine, Brown, Lambert, Donegan, & Eckman, 1998; Fowler, Johnson, & Atkinson 1985; Fowler et al.,

1988; but see Eaton, Haye, Armstrong, Pegelow, & Thomas, 1995). The present report suggests that illness frequency may have an impact on academic attainment that is somewhat independent of academic achievement skills. It is interesting to note that although hematocrit showed a medium-size correlation with cognitive ability and although cognitive ability showed a large correlation with academic outcomes, this disease factor did not appear to relate to poor academic outcomes for either attainment or achievement. These relationships suggest that the effects of SCD on school outcomes may be complex. An additional disease factor important for academic outcomes that was not assessed in this study was the prevalence of silent cerebral infarcts (Schatz et al., 2001). It is unknown the extent to which this disease factor is responsible for the rate of attainment problems found in the current study.

The second finding from this study was that attainment and achievement appeared to be overlapping but independent constructs. This interpretation of the data was further supported by the regression models that indicated that the two outcome measures had different predictors. It is possible, however, that the limited testing of academic achievement (two measures) in the present study may have biased the data so that children with attainment problems were less likely to show basic academic achievement delays than that presented in a study using a more complete achievement battery. This important methodological shortcoming indicates some caution in interpreting this aspect of the data; however, two findings suggest that any such bias in the data does not fully account for the independence of the two measures. First, the discrepancies across the two measures were evenly divided across problems with attainment or achievement only. The bias listed here increases the number of children who show only delays in academic attainment. Second, a prior study using a more complete achievement battery showed a higher rate of academic attainment problems than that predicted from academic achievement levels for children with SCD and cognitive deficits (Schatz et al., 2001). Thus, the data across these two studies favor viewing attainment and achievement as related but different constructs.

The present study supports the validity of cognitive and academic achievement tests as useful predictors of functional school outcomes. Although there is already significant literature linking psychometric test performance with functional outcomes in the general population (Sattler, 2001), validating these relationships within specific populations is also important. It would be useful to further establish the impact of academic attainment

problems in SCD in terms of graduation rates, employment outcomes, and similar long-term outcomes. A second implication of the present findings is that tests of academic achievement used in isolation to measure academic performance may underestimate the severity and rate of academic problems in the SCD population. A combination of achievement and attainment measures provides a more complete view of the functional effects of SCD.

Future studies should examine specific individual and environmental factors (e.g., attitudes about school, social supports, school environment) that could potentially serve as protective factors for academic attainment problems. There appears to be a low level of knowledge among educators that academic problems can be related to the direct or indirect effects of a chronic illness (Finke, Kellett, Schatz, & Robinson, 2002; Robinson, Kellett, Schatz, Carroll, & McRedmond, 2001). This lack of awareness may limit the provision of educational resources in some circumstances (Herron, Bacak, King, & DeBaum, 2003). Educators need more information about potential effects of SCD in the classroom, and children with SCD who are struggling need greater advocacy for appropriate academic interventions.

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Note

1 The author has compared the measure of general cognitive ability used in this study to prorated WISC-III full-scale IQ (Wechsler Intelligence Scale for Children—third edition; based on Coding, Similarities, Picture Arrangement, Block Design, Vocabulary, and Digit Span subtests) in a group of 32 children with epilepsy (ages 6–16 years, $M = 10.1$, $SD = 3.8$, WISC-III full-scale IQ range = 68–112). WISC-III IQ correlated highly with the cross-battery general cognitive ability score (Spearman $r = .88$; Pearson $r = .93$). The cross-battery scores were, on average, 2.3 standard score points higher than those for the WISC-III IQ, $t(32) = -2.07$, $p < .05$.

