

The Cognitive and Academic Impact Of Sickle Cell Disease

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ABSTRACT: Sickle cell disease (SCD) affects over 30,000 students in the United States. Central nervous system complications are widespread among students with SCD and include stroke, silent cerebral infarction, and cognitive impairment. The effects of these complications may lead to academic failure, limited career options, and for some, total disability. Despite studies describing the significant academic and cognitive impact of sickle cell disease, reports describing interventions are limited. There is a lack of awareness among educators of the academic risks associated with sickle cell disease and a lack of appropriate resource allocation. The school nurse, as community health advocate, will be called upon to bridge the gap among healthcare providers, parents, students, and educators. This article provides a review of both recent and landmark studies describing the cognitive and academic impact of sickle cell disease and discusses the role of the school nurse as an advocate, liaison, and educator.

KEY WORDS: absenteeism, academic failure, cognitive impairment, sickle cell disease, silent cerebral infarction, stroke

INTRODUCTION

School nurses face a multitude of tasks with the rising rate of students diagnosed with chronic illnesses. Students with sickle cell disease (SCD) have a genetically acquired blood disorder that makes their chronic illness relatively invisible. These students are usually mainstreamed into the regular classroom within the school system, but as many as 50% of students with SCD will fail at least one grade (Javid, 1999). It has been reported that there is a lack of knowledge among educators concerning the academic implications of the direct and indirect complications from SCD (Schatz, 2004; Freeman, 2003). The role of the school nurse is critical to improving the academic status of students with SCD. The nurse must have an accurate and comprehensive understanding of the academic and cognitive impact of SCD and be ready to imple-

ment specific interventions. These interventions include promoting classroom educator awareness, developing individualized health care and educational plans, and referring the child and family for services as indicated by the individual need of the child.

OVERVIEW

SCD is one of the most prevalent genetic disorders, affecting over 70,000 people in the United States; approximately 30,000 of these are students. Although SCD primarily affects those of African heritage, it is also found in persons of Mediterranean, Caribbean, South and Central American, Arabian, or East Indian ancestry (National Institutes of Health, Lung and Blood Institute, 2004). SCD includes a group of genetic diseases characterized by the predominance of sickle hemoglobin in erythrocytes. The most common genotypes of SCD include hemoglobin SS (Hb SS), hemoglobin SC (Hb SC) disease, and sickle beta thalassemia. The clinical manifestations of SCD are the result of a single substitution in the gene encoding the human beta globin subunit of the hemoglobin molecule (Bunn, 1997).

Individuals with SCD have erythrocytes that con-

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tain predominantly sickle hemoglobin instead of normal adult hemoglobin. In a low oxygen environment, hemoglobin S polymerizes and forms long, rigid fibers that distort erythrocytes into the sickle shape. Sickled erythrocytes cause severe hemolytic anemia and occlude the microvasculature, causing tissue ischemia and acute and chronic organ dysfunction. Ultimately, all organ systems are at risk for damage.

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The most common SCD complication and most common reason for hospitalization is the vaso-occlusive pain episode. Pain episodes vary in intensity, location, quality, and temporal patterns and are classified as acute (caused by blocked red blood cell flow) or chronic (caused by damage from repeated pain episodes and tissue ischemia) (Franck, Treadwell, Jacob & Vichinsky, 2002). The typical vaso-occlusive pain episode requiring hospitalization lasts approximately 10 days (Jacob et al., 2005). While absenteeism has a major impact on the academic attainment of students with SCD, the focus of this article is on the cognitive and academic impairments secondary to the central nervous system pathophysiology of the disease.

Central nervous system (CNS) complications are among the most devastating manifestations of SCD. While most SCD complications are episodic in nature, CNS complications may have an impact on a child's daily life. CNS complications are widespread among persons with SCD and include overt stroke, silent cerebral infarction (ischemic changes with no clinical history of stroke), and cognitive impairment. The overall effect of these complications can be academic failure and consequently a lifetime of limited career options or total disability.

Central Nervous System Complications

Childhood strokes usually result from the stenosis and subsequent occlusion of large intracranial arteries, typically the middle cerebral and intracranial internal carotid. In general, the pathophysiology involves damage to the vessel wall by sickled red blood cells, causing hyperplasia of the vessel's intimal lining. Thrombogenic and inflammatory processes contribute to further thickening, and eventually complete vascular occlusion occurs with resultant ischemia and neurological damage. In children without a clinical history of stroke, a number of possible factors related to the pathophysiology of cognitive impairment have been proposed: (a) recurrent micro-infarction of the central nervous system; (b) hypoxic damage to the brain secondary to chronic anemia; (c) hypoxic damage exacerbated by acute events; and (d) chronic nu-

tritional deficiency associated with increased metabolic demands (Brown et al., 2000).

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The incidence of stroke in children with SCD is approximately 250-fold higher than in the general pediatric population (Ohene-Frempong, 1991), and about 11% of children with genotype Hb SS will suffer a clinical stroke before adulthood (Ohene-Frempong et al., 1998). However, brain damage can be present in children with SCD without clinical evidence of stroke. Silent cerebral infarction, defined as an ischemic change in brain tissue in a person with no clinical history of stroke, is seen by magnetic resonance imaging (MRI) in about 17% of those with Hb SS disease and 3% with Hb SC disease (Moser et al., 1996). Both overt stroke and silent cerebral infarcts affect cognitive function. Pervasive cognitive deficits exist in children with a history of stroke, and although less severe, a pattern of impairment in children with silent cerebral infarct exists (Armstrong et al., 1996). Furthermore, children with Hb SS and normal MRI findings can have cognitive deficits and a decline in performance over time (Steen et al., 2002; Wang, Grover, Gallagher, Espeland, & Fandal, 1993).

Neuropsychological Testing

The fact that stroke has a measurable impact on cognition is well accepted. Children with a clinical history of stroke are at the greatest risk for neuropsychological abnormalities. Their global intellectual function is often in the borderline to moderately impaired range. In a report by Armstrong and colleagues (1996), Full Scale Intelligence Quotient (IQ) scores for children with overt strokes were approximately 70, and Verbal IQ and Performance IQ scores were equally diminished.

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The cognitive impact on children without overt stroke is also well supported. Studies with the largest number of participants were generated from the Cooperative Study of Sickle Cell Disease, a multi-institutional prospective longitudinal study of children with SCD. Between 1989 and 1998, standardized magnetic resonance imaging (MRI) of the central nervous system was performed in a cohort of over 350 school-

age children with SCD in order to correlate abnormalities seen on brain imaging with concurrently obtained neuropsychometric measurements. Using the first set of neuropsychometric and MRI examination findings from the Cooperative Study of Sickle Cell Disease, children with silent cerebral infarcts on MRI performed significantly poorer than children with no MRI abnormality on tests of arithmetic, vocabulary, visual motor speed, and coordination (Armstrong et al., 1996). In 2001, Wang and colleagues reported the results of serial neuropsychometric evaluations over a ten-year time span. In children with Hb SS disease and normal MRI findings, the researchers identified a progressive decline in neuropsychometric performance of approximately 0.5 points per year in Verbal IQ and a decline of 0.9 points per year in mathematics scores on achievement tests. In addition, there were age-related declines on tests of psychomotor speed and focused attention.

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Although the majority of recent reports of neuropsychological testing have found significant differences in performance between children and controls, the methodology of these studies has not been consistent. Some studies included only children with Hb SS disease, others included both Hb SS disease and Hb SC disease, while some studies did not distinguish genotypes. The age and number of subjects and control group characteristics also varied considerably. Some studies measured only global IQ rather than examining specific areas of cognitive functioning. In addition, not all studies included MRI exams to determine the presence of silent cerebral infarcts. Schatz and colleagues (2002) analyzed 18 methodologically diverse studies published between 1963 and 2001 to further evaluate the effects of sickle cell disease on cognitive function. These studies included primarily subjects with Hb SS disease. The mean age ranged from 9 to 18 years, and the number of study subjects ranged from 8 to 373. Control groups were siblings or demographically matched peers. Studies documenting the impact of stroke on cognitive impairment were excluded in the review due to prior establishment of damage. This review concluded that:

- Among all studies, the overall difference in IQ

scores between children with SCD and comparison children was 4.3 standard score points.

- The use of MRI examination to exclude for silent cerebral infarct did not diminish the size of this IQ difference.
- Among those studies examining differences in both IQ and specific cognitive domains, 50% found differences in IQ, and 71% found differences in specific cognitive areas. Studies not showing differences had significantly fewer participants.
- There is no evidence that the choice of control groups affects outcomes for cognitive function.
- There is suggestive evidence that the difference in IQ points increases as participants age.

Early Onset of CNS Damage

Although the majority of studies describing neuropsychological testing have been performed in school-age children, there is increasingly strong evidence that injury begins in children less than 5 years of age (Steen et al., 2002; Steen, Xiong, Mulhern, Langston, & Wang, 1999; Wang et al., 1993). A report from the Cooperative Study of Sickle Cell Disease was one of the first to document evidence indicating early onset damage. The Denver Developmental Screening Test was administered to 344 children younger than 6 years of age from 12 sickle cell centers. More numerous abnormal and questionable scores were present in the older age group, suggesting performance is relatively normal before age 3 with a decline occurring shortly thereafter (Wang et al., 2001).

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Two studies have demonstrated that young children with sickle cell disease have deficiencies in school readiness skills. A study was conducted to determine whether Hb SS disease delays preschool development in children 4 to 6 years of age. Ten affected children and 10 normal subjects matched for age, sex, and race were studied. School readiness was evaluated by the Pediatric Examination of Educational Readiness, which generates a set of observations of the child's strengths and weaknesses that might be helpful in planning health, education, and developmentally oriented services. The children with Hb SS scored significantly lower than their normal counterparts on several parameters, including visual input, sequential input, short-term memory, and fine motor

output (Chua-Lim, Moore, McCleary, Shah, & Mandak, 1993).

In the second study, the hypothesis was tested that young children with SCD are at risk for cognitive impairment. Children were assessed using the Developing Skills Checklist, a teacher-administered test given in the classroom to measure kindergarten-appropriate skills. Using data from a local school district, Developing Skills Checklist scores for 34 children with SCD were compared to a matched group of control children. Children with SCD scored significantly lower than controls in auditory discrimination, a skill necessary for phonics instruction and eventually for reading. In addition, the children with SCD exhibited a trend toward lower scores in language (Steen et al., 2002).

Academic Impact

Reports have documented the problematic effects of SCD on academic performance. In addition to the direct impact of the disease on the brain, frequent school absences due to sickle cell complications also contribute to poor academic performance. Nettles (1994) reported that the academic performance of children with SCD is far below their matched comparison group and below the national norms. Both children with Hb SS and Hb SC disease had reading and mathematics achievement scores that fell within the 26th to the 36th percentile, which is significantly below the national average. They also scored below the comparison group in grade level performance by 3 years and below their own mean school grade. In addition, the children experienced excessive absenteeism. Children with Hb SS disease missed an average of 30 days per year, and those with Hb SC disease missed an average of 20 days per year. Reasons for absenteeism were not ascertained in this study; however, the most common complication of SCD contributing to absenteeism is pain.

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Schatz, Brown, Pascual, Hsu, & DeBaun (2001) evaluated academic attainment, academic achievement, and neuropsychological performance in children with SCD. Subjects were divided into two groups, those with silent cerebral infarct and those without. Healthy siblings were used as the control group. Academic achievement and academic attainment were evaluated as two distinct outcomes. Academic attainment was measured by grade retention attributed to lack of ed-

ucational progress (not excessive absenteeism), and the need for special educational services, defined as the need for special classroom or tutoring services because of poor academic performance. Academic achievement was measured using mathematics and reading achievement test scores; problems were defined by performing 1.5 standard deviations or greater below age expectation on either test.

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Fifty-eight percent of students with silent cerebral infarct were retained or required special academic services compared with 27% of those without silent cerebral infarct and only 6% of siblings. Thirty-seven percent of children with silent cerebral infarct had abnormal achievement test scores, compared with 27% of those without silent cerebral infarct and 6% of siblings. Neuropsychological performance was measured in specific domains: language, visual-spatial/visual motor, memory, and attention/executive. The criterion for abnormality was two or more scores within a domain below 1.5 standard deviations from age expectation. For students with silent cerebral infarct, 79% showed a deficit in at least one of the domains, compared with 36% for those without silent cerebral infarct, and 11% for siblings (Schatz et al., 2001).

Another study by Schatz (2004) examined the impact of SCD on academic attainment and the relationship between academic attainment and achievement. Fifty children with SCD, ages 7 to 17 years, were evaluated; comparison children were recruited from the same community to match on age, gender distribution, ethnicity, and socioeconomic status. Of the children with SCD, 31% had academic attainment problems, compared to 14% in the control group. Children with SCD also had more frequent instances of multiple grade repetitions compared to controls (15 vs. 3 cases). Of the 15 children with SCD, five repeated a grade past the 3rd grade, whereas this did not occur with any children in the control group. For children with SCD, the mean reading, math, and cognitive ability scores were all lower than those of the comparison group.

INTERVENTIONS

The academic and cognitive impact of sickle cell disease is significant, yet publications describing interventions are limited. In a pilot trial (Koonts, Short, Kalinyak & Noll, 2004), 24 children with Hb SS disease were randomized to receive a school intervention program or routine services. The school intervention pro-

gram included sickle cell educational literature, a one-hour in-service program for the primary teacher and relevant school faculty, and a one-hour peer in-service program in the classroom. The teacher/faculty in-service program focused on basic sickle cell facts and management of observable complications. The peer in-service addressed such questions as: What is SCD?, What causes SCD?, and What activities are restricted? Group differences in knowledge were tested using the sickle cell general knowledge questionnaire, and group differences in satisfaction were tested using three satisfaction surveys (child, parent, and teacher). Significant differences in knowledge were found between the school intervention program group and the routine services group for teachers, peers, and children with SCD. No differences were found for parent knowledge. Teachers in the school intervention program exhibited greater overall satisfaction; however, no effects were observed for children and caregivers. In addition, children who had received the school intervention program had significantly fewer school absences than children receiving routine services. The authors speculated that parents were less likely to keep their child home knowing that teachers could effectively manage the child's illness at school.

Routhieaux, Sarcone, and Stegenga (2005) tested the effectiveness of an SCD education program for teachers. Eighty-one teachers completed the program that included educational literature and a 30–45 minute presentation covering four domains: (a) inheritance and prevalence, (b) common complications, (c) strokes, and (d) individual education plans (IEPs). Program effectiveness was measured with pre- and post-test scores. Pre-test analysis indicated that teachers lacked SCD knowledge related to inheritance patterns, strokes, silent cerebral infarcts, and IEPs. Post-test scores indicated teachers' knowledge of SCD improved significantly after the intervention (73% to 83%).

Resource Allocation/Awareness

A report by Herron, Bacak, King, and DeBaun (2003) documented inadequate educational resource allocation for students with SCD. Of 39 high-risk students (24 with stroke and 15 with frequent pain crises), only 70% of the stroke group and 13% of the pain group had been evaluated for an IEP.

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onstrated that a majority of teachers, principals, and peers were not aware that a particular child had SCD. Informal discussions with teachers revealed that they attributed the student's fatigue and frequent absences to low motivation, a chaotic family, drug problems, or human immunodeficiency virus. None attributed the problems to SCD (Noll, Ris, Davies, Bukowski, & Koontz, 1992; Noll et al., 1996). In addition, in an abstract and national conference presentation by Freeman (2003), of 87 teachers and faculty surveyed, 40 (47%) reported they were not aware of learning problems experienced by sickle cell students.

IMPLICATIONS FOR SCHOOL NURSING PRACTICE

The school nurse is the integral connection among parents, educators, and the healthcare team and should serve in the role of educator, advocate, and liaison. Over 30,000 students in the United States have SCD, and CNS complications, including stroke, silent cerebral infarct, and cognitive impairment, are widespread among these students. The effects of CNS complications often lead to academic failure, limited career options, and for some, total disability. Numerous studies have documented the academic and cognitive impact of SCD; nevertheless, there remains a lack of awareness among educators of the academic risks and a lack of allocation of resources.

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A professional in-service program to instruct teachers and staff regarding the cognitive and academic impact of SCD is essential. Educational presentations should consist of general SCD information, common CNS complications, an overview of landmark and current studies documenting the cognitive and academic impact, and appropriate interventions. The school nurse should incorporate methods to evaluate knowledge gained and provide literature that reinforces information presented. An *Educators Guide to Sickle Cell Disease* is available at www.Cure4Kids.org/kids and www.stjude.org.

The school nurse should serve as an advocate for appropriate allocation of resources. Students with SCD are eligible for special education services under provisions of the Individuals with Disabilities Education Act (IDEA), which includes classroom accommodation, transportation, parent counseling and training, school health services, audiology, speech pathology services, and psychological services. Other available services include additional time to complete assign-

ments and tests, tutoring, and homebound services for extended absences (Javid, 1999). Eligible children should receive an Individual Education Plan (IEP), a written legal document describing the needed services. IEPs should be developed for all SCD students with or without cognitive impairment.

Students with SCD will not receive the interventions needed without parental disclosure of the disease. Although health information is requested when a student registers for school, it is not always completed accurately or completely. Disclosure of the disease may not occur for fear of the stigma associated with this chronic illness. Informed and nonjudgmental nursing professionals can facilitate open communication with parents and students.

The school nurse plays a pivotal role in the success of students with SCD. The school nurse cannot begin to fulfill this role without a thorough understanding of the disease and its cognitive and academic impact. Most importantly, the school nurse has a responsibility to stay informed about current research related to SCD and, in turn, educate others in the school setting about this potentially disabling disease.

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REFERENCES

- Armstrong, F. D., Thompson, R. J., Jr., Wang, W., Zimmerman, R., Pegelow, C. H., Miller, S., Moser, F., Bello, J., Hurtig, A., & Vass, K. (1996). Cognitive functioning and brain magnetic resonance imaging in children with sickle cell disease. Neuropsychology Committee of the Cooperative Study of Sickle Cell Disease. *Pediatrics*, *97*(6 Pt 1), 864-870.
- Brown, R. T., Davis, P. C., Lambert, R., Hsu, L., Hopkins, K., & Eckman, J. (2000). Neurocognitive functioning and magnetic resonance imaging in children with sickle cell disease. *Journal Pediatric Psychology*, *25*(7), 503-513.
- Bunn, H. F. (1997). Pathogenesis and treatment of sickle cell disease. *New England Journal of Medicine*, *337*(11), 762-769.
- Chua-Lim, C., Moore, R. B., McCleary, G., Shah, A., & Mankad, V. N. (1993). Deficiencies in school readiness skills of children with sickle cell anemia: A preliminary report. *South Medical Journal*, *86*(4), 397-402.
- Franck, L.S., Treadwell, M., Jacob, E., & Vichinshy, E. (2002). Assessment of sickle cell pain in children and young adults using the adolescent pediatric pain tool. *Journal of Pain and Symptom Management*, *23*(2), 114-120.
- Freeman, M. B. (2003). Facilitating academic achievement of school age children with sickle cell disease. Memphis, TN: St. Jude Children's Research Hospital.
- Herron, S., Bacak, S. J., King, A., & DeBaun, M. R. (2003). Inadequate recognition of education resources required for high-risk students with sickle cell disease. *Archives of Pediatric Adolescent Medicine*, *157*(1), 104.
- Jacob, E., Beyer, J. E., Miaskowski, C., Savedra, M., Treadwell, M., & Styles, L. (2005). Are there phases to the vaso-occlusive painful episode in sickle cell disease? *Journal of Pain and Symptom Management*, *29*(4), 392-400.
- Javid, V. R. (1999). Coping with sickle cell anemia: Additional recommendations for school nurses. *Journal of School Nursing*, *15*(3), 42.
- Koontz, K., Short, A. D., Kalinyak, K., & Noll, R. B. (2004). A randomized, controlled pilot trial of a school intervention for children with sickle cell anemia. *Journal of Pediatric Psychology*, *29*(1), 7-17.
- Moser, F. G., Miller, S. T., Bello, J. A., Pegelow, C. H., Zimmerman, R. A., Wang, W. C., Ohene-Frempong, K., Schwartz, A., Vichinshy, E. P., Gallagher, D., & Kinney, T. R. (1996). The spectrum of brain MR abnormalities in sickle-cell disease: A report from the Cooperative Study of Sickle Cell Disease. *AJNR American Journal Neuroradiology*, *17*(5), 965-972.
- National Institutes of Health, Lung and Blood Institute (Ed.) (2004). *The management of sickle cell disease* (4th ed.), Author.
- Nettles, A. L. (1994). Scholastic performance of children with sickle cell disease. *Journal of Health and Social Policy*, *5*(3-4), 123-140.
- Noll, R. B., Ris, M. D., Davies, W. H., Bukowski, W. M., & Koontz, K. (1992). Social interactions between children with cancer or sickle cell disease and their peers: Teacher ratings. *Journal of Developmental Behavioral Pediatrics*, *13*(3), 187-193.
- Noll, R. B., Vannatta, K., Koontz, K., Kalinyak, K., Bukowski, W. M., & Davies, W. H. (1996). Peer relationships and emotional well-being of youngsters with sickle cell disease. *Child Development*, *67*(2), 423-436.
- Ohene-Frempong, K. (1991). Stroke in sickle cell disease: Demographic, clinical, and therapeutic considerations. *Seminars in Hematology*, *28*(3), 213-219.
- Ohene-Frempong, K., Weiner, S. J., Sleeper, L. A., Miller, S. T., Embury, S., Moohr, J. W., Wethers, D. L., Pegelow, C. H. & Gill, F. M. (1998). Cerebrovascular accidents in sickle cell disease: Rates and risk factors. *Blood*, *91*(1), 288-294.
- Routhieaux, J., Sarcone, S., & Stegenga, K. (2005). Neurocognitive sequelae of sickle cell disease: Current issues and future directions. *Journal of Pediatric Oncology Nursing*, *22*(3), 160-167.
- Schatz, J. (2004). Brief report: Academic attainment in children with sickle cell disease. *Journal of Pediatric Psychology*, *29*(8), 627-633.
- Schatz, J., Brown, R. T., Pascual, J. M., Hsu, L., & DeBaun, M. R. (2001). Poor school and cognitive functioning with silent cerebral infarcts and sickle cell disease. *Neurology*, *56*(8), 1109-1111.
- Schatz, J., Finke, R., Kellett, J., & Kramer, J. (2002). Cognitive functioning in children with sickle cell disease: A meta-analysis. *Journal of Pediatric Psychology*, *27*(8), 739-748.
- Steen, R. G., Hu, X. J., Elliott, V. E., Miles, M. A., Jones, S., & Wang, W. C. (2002). Kindergarten readiness skills in children with sickle cell disease: Evidence of early neurocognitive damage? *Journal of Child Neurology*, *17*(2), 111-116.
- Steen, R. G., Xiong, X., Mulhern, R. K., Langston, J. W., & Wang, W. C. (1999). Subtle brain abnormalities in children with sickle cell disease: Relationship to blood hematocrit. *Annals of Neurology*, *45*(3), 279-286.
- Wang, W., Enos, L., Gallagher, D., Thompson, R., Guarini, L., Vichinsky, E., Wright, E., Zimmerman, R., & Armstrong, F. D. (2001). Neuropsychologic performance in school-aged children with sickle cell disease: A report from the Cooperative Study of Sickle Cell Disease. *Journal of Pediatrics*, *139*(3), 391-397.
- Wang, W. C., Grover, R., Gallagher, D., Espeland, M., & Fandal, A. (1993). Developmental screening in young children with sickle cell disease. Results of a cooperative study. *American Journal of Pediatric Hematology and Oncology*, *15*(1), 87-91.