NUTRITION AND ITS EFFECTS ON ACADEMIC PERFORMANCE

HOW CAN OUR SCHOOLS IMPROVE?

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SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF ARTS EDUCATION

AT NORTHERN MICHIGAN UNDERSITY

July 28, 2010

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DATE: August 2, 2010

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Abstract

The purpose of this paper was to review existing literature about past research that highlighted studies concerning nutrition and its relationship to brain function, cognition, learning, and social behaviors. There is evidence that school breakfast and lunch programs are not up to par with current United States Department of Agriculture standards and that USDA standards may not be utilizing the latest research about nutrition. Studies have shown that proper nutrition has a direct effect on student performance and behavior in school. Much of the literature I reviewed confirmed that nutrition has a direct effect on neurotransmitters which are important in sending messages from the body to the brain. Specific dietary components were shown to have negative effects on this system, many of which are commonplace in school-aged children's daily eating. Unfortunately, school breakfast and lunch programs, in many cases, inhibit the body's cognitive and energy potentials by not providing proper nutrition. The problem has also added to the obesity rate amongst American students, which also has added to the lower achievement in school. In many studies, cases of socioeconomic status seem to be an indicator of food insufficiency, which is simply the lack of available food to a household. Food insufficiency has been shown to directly affect children's cognitive development. What schools can do to improve upon existing nutritional conditions is a focus of the latter section of the paper. Many schools across the nation have invested in nutrition by way of enhanced breakfast and lunch programs. Some have even gone so far as to grow fresh produce in school gardens. Finally, recommendations are explored and given for ways schools can help improve the nutrition of their food programs, thus taking steps to ensure students are given the energy needed for normal cognitive development and social skills.

Chapter I

Introduction

In an educational world filled with failing schools and apathetic students, state boards of education have searched for answers on how to increase test scores and create school systems where all students receive the best education possible. Amongst the plethora of possible solutions, perhaps they should look first at the nutritional substance of what our school-aged children are eating each day as they struggle through a day of learning. There is a correlation between nutrition and cognition as well as psychosocial behavior; this relationship has been highly under-researched, but there exists many studies that look at the nutritional benefits of many proteins, vitamins, and food substances as they affect learning and brain function. Our schools have the potential to play a vital role in preparing and sustaining our students' potential learning abilities and benefitting their social behaviors by supplying nutritious breakfasts and lunches during school days.

Providing the nation's low-income youth with nutritious food has been a concern for over a hundred years. To see that food insufficient students were adequately fed, school lunch programs began during the Great Depression of the 1930's. From the beginning the program had two goals: to make use of surplus agricultural commodities owned by the government as a result of price-support agreement with the farmers and to help prevent nutritional deficiencies among low-income school children by feeding them nutritious meals. On June 4, 1946 President Truman signed an act known as the National School Lunch Program (NSLP). This was in response to claims that had been made that many American men were rejected from WWII military service due to diet-related health problems. The federally assisted meal program was created to safeguard the health and well-being of the nation's children and to encourage the

consumption of American-grown commodities. The federal government would reimburse schools for student who qualified for free or reduced meals. Students who didn't qualify were able to purchase lunch, and their money was used to off-set the costs of building new facilities for the expanding program. The program started to expand because of the increasing number of women working outside the home during the war (Winchell, 2009).

Since 1946 the National School Lunch Act's laws and regulations have been amended twenty-two times. Today's program has over 100 years of testing, evaluating, and constant research to make sure the program provides the best in nutrition, nutrition education, and foodservice for millions of students. The school lunch program has become so accepted that most Americans don't think of it as welfare (Winchell, 2009). The USDA still maintains control over the program, but there are still funding issues with more than half of school lunches free or reduced. According to the National Nutrition Standards, which are published by the School Nutrition Association, in order for schools to receive federal subsidies for free or reduced lunch meals they must follow Dietary Guidelines for Americans (DGA), which state meals must provide one third of the RDA of protein, vitamin A, vitamin C, iron, calcium, and calories. No more than 30% of the meals calories should be from fat and fewer than 10% of the calories should come from saturated fat. Current regulations require that NSLP meals contain (SNA, 2008):

1) One to two ounces of meat/meat alternative daily

2) 10-14 serving of grains/bread per week

3) One half cup fruit daily

4) One half cup vegetables daily

5) 8 ounces of milk daily

The United States Department of Agriculture (USDA) also oversees the largest school breakfast program in the world. The School Breakfast Program (SBP) was part of the 1966 Child Nutrition Act. The legislation's original goal was to offer breakfast to students from low-income families. It was created as a pilot project to provide meals for children "in poor areas and areas where students had to travel a great distance to get to school" (Kennedy & Davis, 1998, p. 798).

By 1975 amendments to the Child Nutrition Act made the SBP permanent. Congress planned to make the program available in all schools to enrich the well-being of school-aged students. In later years, Congress chose to expand the availability of the SBP, so in 1989 the Child Nutrition Act was once again amended. The Secretary of Agriculture was then required to award funding to states, with schools that had a large proportion of children from low-income families, who wanted to begin the SBP (Kennedy & Davis, 1998).

Like the NSLP, the USDA subsidizes school breakfasts, with the amount of subsidy dependent upon the families' income and size. In order for a school to receive the subsidy it must follow dietary guidelines. The goal of the SBP is to provide one fourth of the recommended daily allowance (RDA) for energy and selected nutrients. According to the School Nutrition Association current meal patterns require that the SBP serve the following on a daily basis (SNA, 2008):

1) One half to two ounces of meat/meat alternative

2) 1-2 servings of grains/bread

3) Three quarters of a cup of fruit/vegetables

4) 8 ounces of milk

Proper nutrition is critical to maximizing brain function and enhancing learning. Helping children develop healthful habits from a young age will aid them in reaching their optimal potential.

Statement of the Problem

This research paper attempts to look at research that addresses the relevance of nutrition and its effects on brain development, cognition, and social behaviors. It will use the research to help develop possible steps that schools can take to ensure that their food programs adhere to the high standards of federal nutrition guidelines that are based upon the latest research. The question remains concerning the United States Department of Agriculture (USDA) and if their nutritional guidelines closely follow the latest research in nutritional health and its effects on brain development and cognition. The same concern for school breakfast and lunch programs exists; schools need to ensure that their programs follow the state and national guidelines. Parents need to make sure that their students are eating school program breakfasts and lunches if they are up to par with USDA guidelines. It is hoped that adequate research exists that is readily available to schools and parents so that children have the opportunity to be as nutritionally healthy as possible for optimal brain function, cognitive development, positive social behaviors, and energy to carry out school activities.

Research Questions

This research paper is based upon and attempts to answer the following questions:

1. What role does nutrition play in students' cognitive development, learning, academic performance, and social behaviors in the school setting?

2. What can our schools do to improve their school breakfast and lunch programs to ensure that students are receiving the best nutritional diet available?

Definition of Terms

body mass index (BMI) – BMI is a number calculated from a person's height and weight. It provides a reliable indicator of body fatness for most people and is used to screen for weight categories that may lead to health problems (CDC, 2000).

food insufficiency - Food insufficiency is when an individual or a family has limited access to or availability of food or a limited or uncertain ability to acquire food in socially acceptable ways (Jyoti et al., 2005).

obesity – Obesity is when the BMI is at or above the 95th percentile for children/adults of the same weight and sex (CDC, 2000).

overweight – Being overweight is when the BMI is at or above the 85th percentile but lower than the 95th percentile (CDC, 2000).

Chapter II

Review of the Literature

Nutrition and Cognition

Relationships between nutrition and brain function have been the focus of much research. Studies have shown the impact of dietary foundations on normal brain functions. Chemical messengers within the brain called neurotransmitters have been studied in conjunction with nutrition. Growden and Wurtman (1980) suggested that the brain can no longer be viewed as an autonomous organ, free from other metabolic processes in the body; instead, the brain needs to be seen as being affected by nutrition, the concentration of amino acids and choline (in the blood) which let the brain create and use many of its neurotransmitters such as serotonin, acetylcholine, dopamine, and norepinephrine. Food consumption is vital to the brain being able to make the right amount of amino acids and choline. These are two precursor molecules obtained from the blood that are needed for the brain to function normally. It is no surprise that what we eat directly influences the brain (Colby-Morley, 1981).

Wood cited Kretsch et al. (2001) showed further possibilities that our nutrition has a role with affecting our cognitive functioning. Studies have been done with school-aged children and point to a direct correlation between poor nutrition and lowered school performance. Iron has also been shown to play an important role in brain function as well. Kretsch et al. cited details from a study done with men aged 27 to 47 that looked at iron and its effect on concentration. Low scores on a concentration test corresponded with lowered levels of iron in the bodies of the subjects. A connection was made between low iron levels in children with attention span; children with iron deficiency anemia have been shown to have short attention spans. Kretsch et al. also found that zinc was another nutrient that had a role with cognition, specifically with

memory. In a test of mental function called verbal memory, scientists found that volunteers' abilities to remember everyday words slowed significantly only after three weeks of a low-zinc diet (Wood, 2001).

Erickson (2006) pointed out five key components, based on research, required to keep the brain functioning correctly. The substances, all found in food, are important to brain development and function. Proteins are found in foods such as meat, fish, milk, and cheese. They are used to make most of the body's tissues, including neurotransmitters, earlier identified as chemical messengers that carry information from brain cells to other brain cells. A lack of protein, also known as Protein Energy Malnutrition, led to poor school performance by children and caused young children to be lethargic, withdrawn, and passive, all of which help affect social and emotional development.

Carbohydrates are commonly found in grains, fruits, and vegetables. Carbohydrates are broken down into glucose (sugar) which is where the brain gets its energy. Fluctuating levels of carbohydrates may cause dizziness and mental confusion, both of which can affect cognitive performance. Eating a carbohydrate-heavy meal can cause one to feel more calm and relaxed because of a brain chemical called serotonin and its effect on mood. Serotonin is created within the brain through the absorption and conversion of tryptophan. Tryptophan is absorbed within the blood and this absorption is enhanced with carbohydrates (Erickson, 2006).

Erickson also noted that fat makes up more than 60% of the brain and acts as a messenger in partial control of aspects such as mood. Omega-3 fatty acids are very important to the optimum performance of the brain and a lack of these fats can lead to depression, poor memory, low IQ, learning disabilities, dyslexia, and ADD. Important foods to consume to ensure an Omega-3 fatty acid diet are certain fish and nuts (Erickson, 2006).

Erickson (2006) discussed vitamins and minerals as an important substance for the functioning of the brain. Most important are the vitamins A, C, E, and B complex vitamins. Manganese and magnesium are two minerals essential for brain functioning; sodium, potassium and calcium play a role in message transmission and the thinking process. Aforementioned in the research, neurotransmitters are crucial to brain function in the transferring of messages. Erickson stated research that shows nutrition is important to the production of key neurotransmitters such as acetylcholine, dopamine, and serotonin.

Furthering the research supporting nutrition and its effects on cognition, Wolpert and Wheeler cite research done by Gomez-Pinilla, a UCLA professor of neurosurgery and physiological science. According to the article, diet, exercise, and sleep have the potential to alter brain health and mental function. Gomez-Pinilla stated that it stands to reason that changes in diet could be used to enhance cognitive abilities. His research has shown that Omega-3 fatty acids such as those found in salmon, kiwi fruit, and walnuts, provide many benefits in improving memory and learning, much of which occurs at the synapses. Omega-3 fatty acids support synaptic plasticity and seem to positively affect the expression of several molecules related to learning and memory that are found on the synapses. Omega-3 fatty acids are essential for normal brain function. The article states that a deficiency in Omega-3 fatty acids can lead to increased risk of attention-deficit disorder and dyslexia. According to Gomez-Pinilla, children who had an increase of Omega-3 fatty acids performed better in reading, spelling, and had fewer behavioral problems (Wolpert & Wheeler, 2008)

Wolpert and Wheeler also highlighted a study in England that found school performance improved among a group of students receiving Omega-3 fatty acids. The article also tells of an Australian study of 396 children between the ages of 6 and 12 who were given drinks with

Omega-3 fatty acids along with other nutrients like iron, zinc, folic acid and vitamins A, B6, B12, and C. These students showed higher scores on tests measuring verbal intelligence, learning skills, and memory after six months and one year as compared to a control group of students who did not receive the drink (Wolpert & Wheeler, 2008).

In the Wolpert and Wheeler article, Gomez-Pinilla suggested that diets high in trans fats and saturated fats negatively affect cognition. These trans fats are found in common fast food and most junk foods. Through these trans fats, junk food affects the brain synapses as well as many molecules that aid in learning and memory. A diet low in trans fats and high in Omega-3 fatty acids can strengthen synapses and provide cognitive benefits (Wolpert & Wheeler, 2008).

Wolfe and Burkman (2000) began by creating an equation: good nutrition + exercise = optimal learning. They support the following questions with research:

1. How does breakfast help kids do better in the classroom?

2. Can certain foods enhance a child's learning or memory?

3. Do supplements help children perform better in the classroom?

Wolfe and Burkman cited research that confirmed proper nutritional support is important to allow the brain to function at its highest ability and to enhance learning. Wolf and Burkman suggested that it didn't take much complication or obscurity through expensive foods and supplements to help students reach their potentials; healthful nutritional habits learned early in life help endure normal physiological and neurological growth and development, which translated into students' achieving optimal learning, defined as the abilities to recall information, to problem solve, and to think critically. Wolfe and Burkman pointed out the importance of utilizing the Food Guide Pyramid for Young Children, which is an adaptation of the Food Guide Pyramid from the U.S. Department of Food and Agriculture. This food guide focuses on food

preferences and nutritional requirements of young children and needs to be the foundation of their diets (Wolf & Burkman, 2000).

Wolf and Burkman stated several dietary components support brain function and neurotransmitter activity, and that scientists recommend a wide range of foods as nutrient sources; the most important known today are protein, fat, B vitamins, iron, chlorine, and antioxidants. Offering students the right food choices and helping them develop positive, healthy eating habits will support optimal functioning of the brain. Eating breakfast helps students to eliminate or reduce stomach pain, headache, muscle tension, and fatigue, all which lead to an interference with learning. School personnel have the perfect access to students' breakfast eating habits and need to utilize the opportunity to teach students good breakfast eating habits, whether at school or home. The negative impact of skipping a meal is also highlighted by Wolfe and Burkman. Without an adequate daily intake of nutrients from food, the body puts learning on a lower shelf below its need to sustain life-support functions. Therefore, in many cases, skipping a meal negatively affected the body and its learning functions. Wolf and Burkman concluded that as many as half of low-income elementary students skipped breakfast and that children who eat a good breakfast at school perform better on standardized tests. Also, they found that children who eat breakfast have improved attention in late-morning performance tasks, retrieve information more quickly and accurately, make fewer errors in problem-solving activities, and concentrate better and perform more complex tasks. Also, what the child eats for breakfast is important. A breakfast comprised of protein, fat, and sugar will prevent drops in blood sugar for several hours, whereas, as breakfast of just starch and sugar will sustain a child for only about two hours. A meal that included food from several food groups was the best for a child who was expects to perform at his or her best in school, educationally and physically. Wolfe and Burkman called

attention to school food programs and contend that such programs need support, not disdain. Every lunch must contain at least one-third of the Recommended Daily Allowance (RDA) for specific key nutrients, and every breakfast must contain one-fourth of the RDA for specific nutrients. School meals must conform to the U.S. Dietary Guidelines and on a weekly average, no more than thirty percent of the calories can be from fat (Wolfe & Burkman, 2000). To sum up Wolfe and Burkman's findings, the performance possibilities of children are very dependent upon their health and well-being; minds that have been given the proper nutrition will perform better on tests and general classroom tasks.

Lahey and Rosen (2010) furthered the research that nutrition affects learning and behavior and suggested that diet can influence cognition and behavior in many ways, which include the condition of not enough nutrition or the condition of the lack of certain nutrients. About one-third of children who completed a food-habit questionnaire had inadequate fruit and vegetable intake. These students also showed poor school performance as compared to those students who had an adequate intake of fruits and vegetables (Lahey & Rosen, 2010).

Zhang, Hebert, and Muldoon (2005) looked specifically at fats in the American diet, as the customary diet of American children and adults is high in total fat, saturated fat, and cholesterol. Zhang et al. sought to identify associations with fat intake and psychosocial and cognitive functioning in U.S. school-aged children, since it had been unclear whether and how specific fats may affect social and cognitive development. Data was used from the Third National Health and Nutrition Examination Survey (NHANES III). Medical and cognitive examinations and interviews were conducted with children and proxy respondents. A total of 5,367 children aged 6-16 participated in the Household Youth Interview. After attrition, a total of 3,666 children remained for the analyses (Zhang et al., 2005).

Mothers were asked a series of questions concerning their children's behaviors and social skills. Children were administered the Arithmetic and Reading Subtests of the Wide Range Achievement Test, Revised (WRAT-R) and the block design and digit span subtests of the Wechsler Intelligence Scale for Children, Revised (WISC-R). The WRAT-R arithmetic subtest consists of oral and written problems ranging from addition to calculus, and the Reading subtest assesses letter recognition and word reading skills (Zhang et al., 2005).

A twenty-four hour diet recall interview was administered to the proxies of the children in the study using a trained dietary interviewer using the Dietary Data Collection System designed to probe for fat and salt used in the preparation of foods. The interviewees were asked to report all foods and beverages consumed during the previous twenty-four hours, from midnight to midnight. Also, proxies were asked to rate their children's health as excellent, very good, good, fair, or poor. A dichotomous variable was used that compared the children of the study in fair or poor health with children who were in excellent, very good, or good health (Zhang et al., 2005)

Individuals with a high intake of polyunsaturated fatty acids (PUFAs) had a lower proportion of poor reading performance but a higher proportion of reported difficulties in getting along with peers. However, increasing or decreasing total fat or saturated fat was not associated with cognitive functioning Zhang et al. (2005).

There are a few possibilities that the data obtained from the interviewees could have been inaccurate. This is always a possibility with studies that utilize interviews. Proxies may have been influenced by the perceived value of a particular response choice such as social desirability and social approval of dietary intake. Also, as with any cognitive test, it is always debatable whether the test actually measures what it was designed to measure. With these possibilities in

mind, the researchers observed poor performance on the digit span test but not the other cognitive test was significantly associated with high cholesterol intake (Zhang et al, 2005).

Kar, Rao, and Chandramouli (2008) examined the effect of stunted growth on the nature of cognitive impairments and on the rate of cognitive development. The study investigated if malnutrition would result in a concentrated impairment and a general slowing in the rate of development of all cognitive processes or these effects could be present for some specific cognitive processes. Effects of malnutrition on cognitive processes were also looked at in relation to impairment without affecting the rate of development and its effect on the rate of development of the cognitive process itself. The participants were identified as being malnourished or adequately nourished in the age groups of five- to seven-year olds and eight- to ten-year olds.

Students in the malnourished group were identified by their height (stunting) and weight (wasting) of children in the same age categories with reference to the national center of health statistics (NCHS). Height for age/weight for height score less than two standard deviations from the mean were considered an indicator for moderate to severe malnutrition. Adequately nourished students were identified as children who were in or above the 50th percentile of height and weight as stated by the NCHS standards. Adequately nourished students were paired with malnourished students with respect to age and grade level. Each group had 20 participants (Kar et al., 2008).

Students were tested individually in a well-controlled environment. The test they were given was the NIMHANS neuropsychological battery for children. It was developed for children aged five to fifteen. The battery consists of neuropsychological tests to assess motor speed, attention, executive function, visuospatial relationships, comprehension, learning, and memory.

Each section was grouped under a specific cognitive domain on the basis of theoretical rationale and factor analysis (Kar et al., 2008).

Kar et al. (2008) compared the performance of adequately nourished children to malnourished children and also compared age related differences in cognitive function and found that the malnourished children differed from the adequately nourished children on tests of phonemic fluency, design fluency, selective attention, visuospatial working memory, visuospatial functions, verbal comprehension and verbal learning, and memory. Results for the verbal fluency test show adequately-nourished children achieved higher mean scores in both age categories, five- to seven- year olds and eight- to ten- year olds (4.3 and 5.7 respectively), when compared to their malnourished counterparts (1.36 and 4.4 respectively). Some of the other results had similar findings such as visual construction adequately nourished in both age categories (10.0 and 15.8) score higher than malnourished students (3.0 and 4.8) in the same age categories and also for verbal learning (32.4 and 42.3 vs. 26.9 and 30.7). These results show age related differences within each group as well as between the two age groups. Kar et al. also found a lack of age-related improvement in malnourished children when looking at cognitive functions of attention, cognitive flexibility, visuospatial construction, ability and verbal learning. Malnourished students showed lower results than the adequately nourished students but they did show age related improvement for these same functions. Differences were tested for statistical significance. Test scores for adequately nourished children between 5- to 7- years olds and 8- to 10- year olds were found significant but most of the test scores for undernourished children showed a delay in development of certain cognitive functions.

Kar et al. (2008) findings should be retested with a larger sample of participants to see if the trend is consistent with not only malnourished and adequately nourished children but those who are obese from an unhealthy diet.

Li, Dai, Jackson, and Zhang (2008) examined the associations between academic performance, cognitive functioning, and increased BMI. They studied a nationally representative sample of 2,519 children ages eight to sixteen years old. Each participant had completed a brief neuropsychological battery and measures of height and weight. Trained examiners administered tests in a standardized environment using uniform procedures. Body weight was measured to the nearest 0.05 kg and height was measured to the nearest 0.1 cm. BMI was calculated in kilograms per meter square and then converted to a sex and age specific BMI percentile. Each participant was then categorized to an overweight BMI, an at-risk BMI, or a normal BMI. Parent-reported measures of children's TV watching habits were also surveyed. Children were asked to report how many times per week they played or exercised enough to sweat or breathe hard. This question did not exclude school involvement, but another question about sports and exercise did. Children were then categorized as a participation group or nonparticipation group. Blood pressure, cholesterol, serum triglycerides levels, and iron deficiency were also observed. Iron deficiency has been known to be associated with poor cognitive function, and a high occurrence of iron deficiency was observed among overweight and obese children and adolescents.

The average age of participants was 12 and they were about equally divided in gender. The subjects included differed on most of the characteristics from the subjects excluded. Those excluded were likely to be non-white and come from families with a low socioeconomic status. Among the subjects 20.33% were classified as overweight and 15.92% were obese. Li et al. (2008) found the association between BMI, cognitive functioning, and academic performance to

be noteworthy. Test scores decreased as BMI on increased. The block design test had the greatest discrepancy among participants with 5.04% of normal weight children scoring poorly, 9.19% of at-risk children scoring poorly, and 12.18% of obese children scoring poorly. Test scores were defined as poor when they were less than 2 standard deviations from the mean. The odds of poor performance in visuospatial organization and general mental ability were doubled among at-risk children and tripled among overweight children when compared to normal weight children.

Academic performance was measured by a test designed to assess basic school performance. Li et al. (2008) observed that being overweight was not the root cause of poor academic performance but found that obese adolescents consider themselves worse students. Another result from the study was that decreased cognitive function was associated with increased weight status. Cognitive deficits on tests of motor speed, weakened performance on motor speed and manual dexterity, and executive function were found. Poor performance on memory tasks was also common among obese people. Those with poorer cognitive ability may do worse in school and opt for a lifestyle that promotes weight gain. This study verified that this association may exist among overweight children or children at-risk of being overweight without clinically diagnosed diabetes mellitus, vascular disease, or cardiac disease that often characterize adult patients. Li et al. also found a relationship with decreased block design and weight. Block design is a measure of visuospatial organization and general mental ability which has been shown to be sensitive to brain damage. Results showed that the unfavorable effects of increased body weight on cognitive function start showing as early as childhood. Cognitive function decline may occur in younger persons and findings show an increase body weight worsens other risks factors for cardiovascular disease as time passes.

One of the most concerning outcomes of iron deficiency in children is the change of behavior and cognitive performance. Halterman, Kaczorowski, Aligne, and Szilagyi (2001) looked at the relationship between iron deficiency and cognitive test scores among school-aged children and adolescents. The objective of this study was to evaluate the relationship between iron deficiency and standardized test scores among six to 16-year-old US children. This relationship was considered for both children who had iron deficiency with anemia and for children who had iron deficiency without anemia.

The National Health and Nutrition Examination Survey III (NHANES III) provided cross-sectional data for 5,398 children aged six to 16 and contained measures of iron status including transferrin saturation, free erythroirin status, protoporphyrin, and serum ferritin. Children were considered iron-deficient if any two of these variables were abnormal for their age or gender. Status hemoglobin values were used to detect anemia (Halterman et al., 2001).

Among the 5,398 children in the study, 3% were iron deficient. This translated into 1.2 million school-aged children and adolescents in the United States who have an iron deficiency. Iron deficiency with or without anemia was determined for children with different age, gender, and demographic characteristics. Iron deficiency without anemia was more widespread than was iron deficiency with anemia. Iron deficiency was less than three percent among six- to 11-year-old children. Among 12- to 16-year-olds, iron deficiency was common among 8.7% of females, but only 0.9% of males (Halterman et al, 2001).

Halterman et al. (2001) examined results from the Standardized Test and found a trend of lower scores with diminishing iron status. This trend was most evident in math. Math scores were lower for the iron-deficient children without anemia compared to normal iron status children. Children with anemia also had lower math scores when compared to children with

normal iron status. Seventy-one percent of children with an iron deficiency scored below average in math as well as 72% of children anemia. Only 49% of children with normal iron status scored below average. There were no real discrepancies found among these students with reading, block design, and digit span but children with normal iron status performed better. Results from this comparison were adjusted for age, gender, race, poverty status, caretaker education, and lead status.

There were potential limitations with this study. First, there were a limited number of cognitive measures available in the NHANES III data base. Therefore, iron deficiency with other cognitive scores could not be assessed. Secondly, the small number of children in certain subgroups may have allowed some associations to go undetected. Also there was no way to determine whether or not the sample students were iron deficient as infants and it is not known at this time whether the association of iron deficiency in older children and lower math scores would continue after treatment with iron.

The 3% of children in this sampling with iron deficiency represent over a million school-aged children and adolescents. Iron-deficient children without anemia represent the largest portion of children with an iron deficiency. Halterman et al. (2001) suggested this should be an important health concern. Halterman et al. (2001) proposed a need for screening not only for iron deficiencies with anemia but for those high-risk children without anemia.

Food Insufficiency

Alaimo, Olson, Frongillo, and Briefel (2001) examined the relationships between family income, food insufficiency, and health among US children. For this study, food insufficiency was defined as “an inadequate amount of food intake due to lack of resources” (p.782). A child

was classified as “food insufficient” if the proxy reported that the family either “sometimes” or “often” did not get enough food to eat.

Data were analyzed for children aged six to eleven and twelve to sixteen. Medical and cognitive examinations and interviews were conducted with survey participants and proxy respondents, and data from the Household Family and Household Youth Questionnaires (proxy interviews) and Youth and Proxy Questionnaires that were conducted in mobile examination centers. All interviews were administered using trained interviewers. Cognitive functioning was assessed using two subtests of the Wechsler Intelligence Scale for Children, Revised (WISC-R). The Block Design subtest is a perceptual organization exam in which children construct designs out of blocks to match a model. The Digit Span test is a freedom-from-distractibility exam in which children are asked to repeat up to eight digits in forward and reverse directions. Academic scores were assessed using two subtests of the Wide Range Achievement Test-Revised (WRAT-R): Reading and Arithmetic (Alaimo et al., 2001).

Alaimo et al. (2001) found that for both younger children and teens, WRAT and WISC scores were about 1.3 to 2.5 points (on a scale to 20) lower for food insufficient children than for food sufficient children. Also, food insufficient children and teenagers were more than twice as likely to have repeated a grade and missed more school days. Forty percent of food insufficient teenagers had repeated a grade as compared with only 20.7% of food sufficient teenagers. Food insufficient children and teenagers were also more likely to have psychosocial problems than those who were food sufficient: food sufficient teenagers were more than twice as likely to have seen a psychologist, almost three times as likely to have been suspended, almost twice as likely to a lot or some difficulty getting along with others, and four times as likely to have no friends. Results of this study show that family food insufficiency is associated with school-aged

children's academic and psychosocial development and show the negative consequences of food insecurity and hunger for American children. Looking further into the study, School Lunch and Breakfast Programs have shown small but significant benefits in cognition, academic achievement, and school absence (Alaimo et al., 2001). The study has identified an association but not necessarily a cause and effect situation. The correlation between food insufficiency and lower income families points to the correlation between low incomes and poor academic performance. Whether either food insufficiency or low income causes poor academic performance and cognition remains to be proven.

Obviously, not having enough food to eat creates health risks for children. Alaimo et al. demonstrated that being from a food insufficient family has a negative impact on a child's health. Food insufficient children were more likely to experience issues that would impact their health through biological means such as reduced food intake, food quality, or micronutrient deficiencies and psychological issues through increased stress, worry, and feelings of deprivation. This study demonstrated an association between food insufficiency, poverty status, and children's poor health. Food insufficient children are at an increased risk of poorer health. Alaimo et al (2001) suggested that food security is a critical part of a child's overall health and well-being and should be of utmost importance to ensure that all children are adequately fed.

Jyoti, Frongillo, and Jones (2005) studied the relationship between household food insecurity and selected aspects of children's academic, social, and physical development over a four year period that spanned from kindergarten to third grade. The selected developmental outcomes were mathematics performance, reading performance, weight, BMI, and composite social skills. Data were acquired from the Early Child Longitudinal Study – Kindergarten Cohort (ECLS – K). The sampling of students for whom full data was available at both kindergarten and

third grade was 11,400. Full data were required from a scored reading or mathematics assessment and parent completion of the USDA food security module. Any fluctuations in food security over the four year span respondents were categorized into four groups: remained food secure at all times, remained food insecure at all times, transitioned from food security to food insecurity, and transitioned from food insecurity to food security. Students were given a battery of test to assess reading and mathematics ability. The tests were conducted individually in both kindergarten and third grade. Students' heights and weights were assessed directly in both kindergarten and third grade, and BMIs were calculated from heights and weights. Social skills were assessed by the teacher using a questionnaire in which teachers rated how frequently their students displayed certain social skills such as approaches to learning, self-control, interpersonal skills, and externalizing and internalizing problem behaviors. Change in social skills scores were calculated by subtracting the kindergarten composite score from the third grade composite score.

Between kindergarten and third grade, 77.9% of children's households remained food secure, 6.0% remained food insecure, 9.7% became food secure, 6.5% became food insecure. Food insecurity was experienced at one or both times in 22.2% of the sampled households. Jyoti et al. observed outcomes that were expected for the ages and developmental stages of the children in the survey. Children from food insecurity households at kindergarten showed a 2.34-point smaller increase in mathematics score, a 4.39-point smaller increase in reading score, a 0.27-U greater gain in BMI, a 0.44-kg greater gain in weight, and a 0.08-point greater decline in social skills score than children from food secure households at kindergarten. Children transitioning from food security to food insecurity demonstrated a 3.21-point smaller increase in reading score ($P < 0.0007$) when compared to students who remained food secure. Children transitioning from food insecurity to food security showed a 1.50-point smaller increase in

mathematics score ($P < 0.005$) when compared to children from households remaining food secure. Children from households that became food insecure were associated with a smaller increase in reading score ($P < 0.005$) than students from households that became food secure (Jyoti et al., 2005).

Jyoti et al. (2005) set out to examine the effects of household food insecurity at kindergarten on consequent selected proportions of childhood development. Their findings suggested food security at kindergarten predicted impaired academic performance in reading and mathematics, a greater decline in social skills for boys, and greater weight and BMI gains for girls. Food insecurity served as an indicator for identifying children with deferred courses of development. Jyoti et al. examined the relation of change in food insecurity over time and concurrent development and found children from households that became food insecure demonstrated poorer reading and mathematics performances.

Brown, Executive Director of The Center of Hunger and Poverty (2002) reported research findings that support Jyoti et al. (2005) and Alaimo et al. (2001) findings on health consequences and psychosocial and behavioral impacts. The Center of Hunger and Poverty reviewed 21 studies to gain a clearer picture of how food insecurity affects the nation's children. Findings showed food insufficient children are more susceptible to illnesses and infections such as sore throats, colds, stomachaches, and headaches. Iron deficiency anemia is also associated with hunger and food insecurity. Children from food insecure households tend to experience psychological and emotional distress with behavior problems such as hyperactivity, aggression, and withdrawn behaviors. Food insecure children have difficulties getting along with their peers, being suspended from school, and a need for special counseling and education services. Children under 12 frequently experience fatigue, irritability, and have difficulty concentrating. Children

from food insecure households demonstrate aggressive, withdrawn, distressed behavior. Older children from food insecure homes show difficulty getting along with others and were likely to report having no friends. Family food insecurity was associated with depressive disorders and suicidal behaviors for 15- and 16- year olds. National sampled teenagers were twice as likely to have seen a psychologist, to be receiving special education services, and have a history of mental health counseling.

The Center on Hunger and Poverty (2002) reported that persistent or involuntary lack of food over time may result in malnutrition. Mild-to-moderate malnutrition can be a developmental risk factor. Malnutrition can limit a child's ability to comprehend even basic skills and weaken overall learning potential. Children from food insufficient households may not perform as well on academic achievement tests as children from food sufficient households. Students who experience food insufficiency are likely to repeat a grade in school and experience tardiness or absences from school which may affect their academic performance.

Another association with food insufficiency presented (Center, 2002) is obesity. Obesity may be a survival response to episodic food insufficiency that occurs from overeating when food is abundant. Obesity may also occur from the ingestion of low-cost, high fat foods which are purchased to prevent hunger when a household lacks money to buy nutritious foods. Studies linking food insecurity and overweight/obesity are new and researchers are looking into these trends to see how valid they are. There are no strong trends but research suggests the importance of distinguishing between different age, race/ethnicity, and the relative sensitivity of various measures of food deprivation.

Kleinman et al. (2002) examined the relationships amongst dietary intake and hunger, student participation in school breakfast programs, psychosocial functioning, and academic

performance in school. In the last 20 to 30 years, there has been an increasing amount of chronic to mild food deprivation, which has been defined as food insufficiency or hunger. Kleinman et al. utilized a Boston Public Schools universal-free school breakfast program. Initially, a total of 227 students were invited to participate in the study; students ranged in grade level from 4th through 6th grade, and only one child per family invited was eligible to take part. Due to unavailability and unreturned permission slips, a much smaller sample of 97 students were able to complete the study interviews (Kleinman et al., 2002).

Kleinman et al. (2002) administered a questionnaire during an initial interview with parents in order to gather data concerning the children's age, gender, ethnicity and parental marital status. A 24-hour dietary recall was the instrument utilized before and after the initialization of the school breakfast program. Recommended Daily Allowance (RDA) percentages were used in conjunction with dietary intake evaluation for nutrients and energy specific to the study. Food service staff from the three Boston public schools involved in the study provided data concerning student participation for one week prior to the starting or the universal-free school breakfast program (USBP), and they did the same for one week following approximately 6 months of the USBP. Measurement conducted in the study allowed for a range of participation amongst students. "Often" was the standard for those who ate breakfast 80% or more of the days they were present in school; "sometimes" was used for those who ate between 20 and 79% of the days present; "rarely" was used to indicate those students who ate breakfast in school less than 20% of the days they were present (Kleinman et al., 2002). Other instruments such as the 8-item hunger/food insufficiency questionnaire and the 5-item Child Hunger Index Child Report were conducted by the researchers. Parents and students filled these questionnaires out respectively as pretest data. In order to help determine whether dietary intake or hunger had

an effect on academic performance scores, school records for the participants were reviewed in the disciplines of math, reading, science, and social studies. In addition, student records were consulted for data on absence and tardy rates (Kleinman et al., 2002).

Results of the originally-mentioned questionnaire filled out by parents showed that the socioeconomic and ethnic characteristics were pretty much the same for all three schools in the study and that more than 70% of the students were able to receive free or reduced meals at school, and more than 70% of the students were of African-American or Hispanic descent. A bit less than half (41%) of the participating students were male, and 2% were in grades 3 through 5 (elementary grades). Only 18% were from the 6th grade, considered middle school in the district. Fifty-five percent of the participating students came from single-parent families (Kleinman et al., 2002).

Kleinman et al.'s (2002) results showed that the mean grade point average of students who experienced higher or adequate intakes of nutrients and energy during the study was 2.8 on a 4.0 grade scale. The mean grade point average of the students who experienced a much lower intake of nutrients and energy was 2.1 on the same grade scale. The four academic areas showed the same patterns with lower letter grades for the students who were termed at risk nutritionally as compared to those student participants who were termed not at risk. Absenteeism followed suit, as students who were nutritionally at risk had higher absence rates than those students who were not at nutritional risk. Tardiness did not change significantly enough to matter in the study.

Although strong correlations exist in the study done by Kleinman et al. (2002), there are certainly reasons for questioning their results. First, the sample size was significantly smaller than the original number intent. It was also mentioned that the sample was "primarily of low income" (Kleinman et al, 2002) which may skew results because of the rates of child hunger and

school breakfast intake in a single area of the country. Also, a 24 hour dietary recall may not be reflective of each participant's actual nutritional intake of the study period of six months. Despite these possible red flags in this study, Kleinman et al. brought to light the relationships that exist amongst dietary intake, behavior, and academic performance.

Shore et al. (2008) investigated whether there were differences in school achievement between overweight and non-overweight middle school students as measured by objective school data. The records of five hundred sixty-six students were analyzed in the study and categorized into three sections: academic achievement, attendance and discipline, and physical fitness and athletic team participation. Student GPAs reflected the cumulative average from the grades earned over four marking periods. Reading comprehension scores were gathered from the nationally-standardized test, the degree of reading power (DRP) test, which assessed reading comprehension of nonfiction text. This test was administered to all students during the first month of school by a certified teacher for purposes other than Shore et al. study. Attendance and discipline measures were gathered from year end records for the number of days absent, number of day's tardy, number of administrative detentions assigned, and number of days suspended from school. Physical fitness and athletic team participation data were obtained from assessments given by a certified physical education teacher during the school day in physical education classes. Students were assessed on curl-ups, shuttle run, endurance 1-mile run/walk, pull-ups, and sit and reach. Height and weight of all students was also converted into BMI percentile scores using the 2000 Centers for Disease Control (CDC) weight by age and gender tables. Students were placed into one of three categories: non-overweight (BMI% percentile <85), At-risk for overweight (BMI% percentile 85-94), or overweight (BMI% >94). There were 406 non-overweight students, 85 At-risk for being overweight students, and 58 overweight

students. Also recorded was the participation of seventh grade students on school-based interscholastic athletic teams.

Shore et al. (2008) found differences in non-overweight students and overweight students in the areas of academic achievement, attendance and discipline (with the exception of suspension), and DRP scores. The GPAs of non-overweight students were about 11% higher than those of the overweight students. At-risk for being overweight students had a higher GPA than overweight students (3.35 vs. 3.06). Results for the DRP test showed the average national percentile rank for non-overweight students to be 74.9% and overweight students to be 66.0%. The group of students labeled At-risk of being overweight was in the 74.4% ranking. Detentions also showed a difference with overweight students five times more likely to have six or more detentions than non-overweight students. Non-overweight students had 25% fewer absences and 39% fewer days tardy than overweight students. Non-overweight students performed better than their peers in the other groups when controlling for demographic variables. The most notable differences in performance among all three groups were on weight dependent tasks such as pull-ups (non-overweight 65.81, at-risk 51.23, and overweight 47.50), shuttle run (66.09, 51.25, and 37.65), and 1-mile run/walk (62.06, 41.79, and 25.92). In the seventh grade 75% percent of all non-overweight students participate in at least one school-based athletic team, whereas only 61% of at-risk and 33% of overweight students do.

Shore et al. (2008) suggested that non-overweight students demonstrated better grades, a tendency toward higher reading scores, better attendance, and less discipline when compared to overweight students. The study was limited though by the looking at only students from one school, a narrow age range, and data gathered from only one time period. Results were adjusted

for gender, ethnicity, and socioeconomic status, which were determined by students' enrollment in the free or reduced lunch program.

Geier et al. (2007) examined the association between relative weight and absenteeism in 1,069 fourth through sixth graders from nine kindergartens through eighth grade. The fourth through sixth grade students were part of an ongoing randomized control trial to assess prevention strategies for obesity in low socioeconomic samples. Schools participating in this control trial had to have at least 50% of the students eligible for free or reduced lunch. Both parental consent and child assent were required. Each participant was classified into one of four weight groups as described by the Institute of Medicine: underweight: BMI-for-age <5th percentile (n = 23; 2.2%), normal-weight: BMI-for-age 5th to 84.9th percentile (n = 619; 57.9%), overweight: BMI-for-age 85th to 94.9th percentile (n = 182; 17.1%), and obese: BMI-for-age >95th percentile (n = 245; 22.9%).Geier et al. found nearly 40% of the students in the sample were overweight or obese. Weight was measured in the second semester of the academic year to the nearest 0.1 kg and height was measured twice at one time Geier et al. found nearly 40% of the students in the sample were overweight or obese. Weight was measured in the second semester of the academic year to the nearest 0.1 kg and height was measured twice at one time to the nearest 0.1 cm. Home room teachers recorded absentee data first thing in the morning for the entire academic year. If a student arrived prior to third period, the absence was changed to a tardy.

Geier et al. (2007) found that students categorized as underweight were absent an average of 7.5 days, followed by students categorized as normal weight who were absent an average of 10.1 days. Overweight students were absent an average of 10.9 days and obese students were absent an average of 12.2 days. Geier et al. combined obese and overweight students into one

group and underweight and normal weight students into another group. The heavier students missed more days of school when compared to the lighter students (11.7 days vs. 10.0 days). Being obese was associated with almost two more days absent than being normal weight after controlling for age, race/ethnicity, and school.

Geier et al. (2007) had two main findings in their study. The first finding was that obese children were absent (12.2 days) more than normal weight children (10.1 days). After combining the four groups into two, findings were consistent that heavier children were absent from school more often than lighter children. The second finding was that the obese category (BMI-for-age > 95th percentile) remained an indicator to the number of days absent even after data was adjusted for age, race/ethnicity, and gender in a low socioeconomic status population (83% eligible for free or reduced lunch). Being obese was associated with 1.9 days absent after controlling for age, race/ethnicity, gender, and school.

Geier et al. (2007) pointed out three limitations to their study. The first limitation was that the study was cross-sectional and longitudinal studies were better able to examine relationships between overweight children and absenteeism. The second limitation was that the regression model accounted for only 11% of the variance in the number of days absent which may suggest that factors other than BMI, age, race/ethnicity, and gender contribute to the number of days absent. The last limitation was the incapability to analyze socioeconomic status at the participant level.

School Food Programs

Finkelstein, Hill, and Whitaker (2008) studied school food environments and policies in US public school and described how they varied according to school characteristics. The study sample included 395 schools in 129 districts in 38 states. Sixty-three percent of the schools were

elementary schools and half of the schools were in a city or suburban area. Of the sample schools, vending machines were found in 17% of elementary schools, 82% of middle schools, and 97% of high schools. A la carte items were sold in 71% of elementary schools, 92% of middle schools, and 93% of high schools. Checklist data were used to determine whether low-nutrient, energy-dense foods or beverages were available through the competitive food programs.

Seventeen factors were used to characterize school lunches, a la carte and vending machine foods, and other food-related policies. These factors were used to compute a food environment summary score for each participating school. Zero was the least healthy and 17 the most healthy. The questionnaire and menu data survey was made up of 17 yes/no questions that indicated the presence of a "healthy" school food policy or environment characteristics. The survey was grouped in three sections: 1) policies or practices of the district or school; 2) availability of competitive foods; and 3) content of USDA school lunches offered. Questionnaires were administered to the School Food Authority, directors of the school district nutrition programs, the school principals, and the school food service managers. On-site observers used checklists to record foods and beverages that were available in vending machines and served in the a la carte food line during school lunchtime. Data from the on-site visitors' checklists was used to verify the accuracy of the questionnaire data pertaining to vending machines and a la carte items sold in the cafeteria during lunch (Finkelstein et al, 2008).

Finkelstein et al. (2008) found that 73% of the schools were not offering food from a brand-name restaurant, 68% offered nutrition education in every class, and 60% provided nutritious content for school meals. They also found that fewer than half of the schools had a wellness policy or used a government fruit and vegetable program. Less than 25% of the sample

schools had a nutrition or health advisory council, but of the schools that did have a nutrition or health advisory council, 66% involved parents.

A high percentage of schools offered competitive foods through either vending machines, a la carte lunch option, or both. Availability was found to vary throughout the schools. Eighty-three percent of elementary schools and 18% of middle schools didn't have vending machines, but 97% of the high schools did. Forty percent of the high schools also allowed vending machines to be placed in the food service area. Eighty-six percent of schools had no stores or snack bars, and about half of the schools limited the sale of competitive foods and beverages through fundraising activities. These limitations were less common in high schools than in middle and elementary schools (Finkelstein et al., 2008).

Low-nutrient, energy-dense foods and beverages were almost always present in vending machines. Only 15% of secondary schools with vending machines had no access to machines containing low-nutrient, energy-dense foods and beverages. Twenty-one percent of schools didn't offer any a la carte items. This percentage varied significantly across elementary (29%), middle school (8%), and high school (7%). As found in vending machines, a la carte items were almost always low-nutrient, energy-dense food and beverages (Finkelstein et al., 2008).

At half of the schools, in USDA lunches, fruits and vegetables were offered daily, and in one third of the schools, the only type of milk offered was either skim or 1%. In 22% of the elementary schools, the average lunch served had less than or equal to 30% of calories from fat which made it a low fat. In approximately one quarter of the elementary schools French fries and dessert were not offered at all during the target week (Finkelstein et al, 2008).

Finkelstein et al. (2008) found that competitive foods and beverages were commonly available in US public schools and particularly in high schools. Vending machines and a la carte

offering were common sources of food and these were most times low-nutrient, energy-dense foods and beverages. They concluded that school food environments become less healthy as students move to higher grade levels.

One of the limitations this study had was in the SFEP summary score. All items were assigned an equal weight because Finkelstein et al. (2008) had no evidence to establish which items were most strongly linked with the risk of student obesity. They also assumed that the studied policies were established at the school level and not at the district level. Another limitation was that the study did not investigate the hours during which vending machines accessible to students. This information had been collected from school staff, but more than one third of respondents were unable to provide this information and thus limited the ability to analyze these data.

Neumark-Sztainer, French, Hannan, Story, and Fulkerson (2005) examined the association between high school students' lunch patterns and the school food environments and policies. Their study had two specific objectives: 1) to describe school lunch practices and vending machine purchases; and 2) to examine the association between eating patterns of high school students and food environments and policies. One thousand eighty eight high school students from 20 high schools participated in a two- year, group- randomized, and school-based nutrition intervention trial known as TACOS (Trying Alternative Cafeteria Options in Schools). Of the students participating nine percent were eligible for free or reduced lunch. Baseline data were collected prior to the start of the TACOS intervention. Surveys were mailed to a random sample of 75 students from each of the 20 schools. School food policies data was collected with surveys that were mailed to principals and food service directors from participating schools.

Research staff collected data on vending machine availability and hours of operation through site visits.

Neumark-Sztainer et al. (2005) surveyed students' school lunch patterns asking: During a normal school week, how many days per week do you

1) Get lunch in the school cafeteria main lunch line?

2) Get lunch in one of the school cafeteria a la carte or snack bar lines?

3) Bring lunch from home?

4) Get lunch off campus at a fast food restaurant?

5) Get lunch off campus at a convenience store?

Vending machine data was collected with two similar questions: During a normal school week, how many days a week do you

1) Get food from a school snack food vending machine?

2) Get soft drinks from a school vending machine?

Response categories ranged from zero to five days per week. School policies addressing open/closed campus during lunch time and the types of food stocked in vending machines were assessed with the principal survey. Information from the food service director was used when the principal's data was missing or had a "don't know" response. Schools were asked if they had a closed or open campus policy during lunchtime. Vending machines were categorized as snack food vending machines, soft drink vending machines, and "other" vending machines which offered fruit juice, juice drinks, water, and sports drinks. Policies about hours of operation for vending machines were collected through observation. School-level data, such as food related policies and measures of school environments imply that all students are under the same policy. Student eating patterns are individual-level data.

Neumark-Sztainer et al. (2005) found that students ate meals from the main lunch line an average of 2.4 days per week and from the a la carte line 1.8 days per week. On average students brought lunch from home once a week and also purchased from the snack food vending machine once a week. Soft drink were purchased an average of 1.6 days per week with nearly two-thirds (61.5%) of students purchasing soft drinks at least one day per week.

School food environments and policies data showed about two-thirds (68.4%) of schools had a closed campus policy with regard to lunchtime. Only 15.8% of schools had policies dealing with types of food that could be sold in vending machines. Twenty-five percent of the schools with snack food vending machines had them closed during lunchtime, and 55% of the schools with soft drink vending machines had them closed during lunchtime (Neumark-Sztainer et al., 2005).

Neumark-Sztainer et al. (2005) found that students with open campus policies during lunchtime were almost four times as likely to eat lunch at a fast food restaurant and three times as likely to eat at a convenience store as students from school with closed campus policies. Students from schools with vending machine policies reported making snack food purchases an average of 0.5 days per week as compared to 0.9 days per week in schools without policies. A similar trend was found with soft drink purchases. Students' purchases were more frequent as the number of vending machines increased.

This study looked at associations between school food policies and student lunch practices and vending machine purchases. Neumark-Sztainer et al. (2005) found that schools with closed campus policies had fewer lunch purchases from fast food restaurants and convenience stores. Schools with policies regarding the types of foods that can be sold in vending machines had fewer student snack food purchases. Student snack food purchases were

also associated with the number of snack food vending machines. Soft drink vending machines with limited hours of operation were associated with fewer student purchases. This study did find students reported eating the regular school lunch 2.5 days per week for closed campus and 2 days per week for open campus. Students also frequently made purchases from the a la carte menu 1.8 days per week for closed campus and 1.6 days per week for open campus. Foods from the a la carte menu have minimal regulations in terms of nutrition. These foods tend to be high in energy and low in nutrients. The findings also imply that interventions for healthy brown alternatives would be in line because students bring their lunches an average of once a week.

Differences across grade levels were also found. Students in the upper grade levels were less likely to eat a la carte lunches at school and were more likely to purchase lunch outside of school. School-based interventions need to take into account the different eating patterns of all students, regardless of age. Factors likely to influence school eating practices, such as proximity of different food outlets to the school, should be considered. Findings concluded that food policies that limit access to foods high in fats and sugars are associated with less frequent purchase of those items. Neumark-Sztainer et al. (2005) recommended that schools examine their food related policies and consider making changes to decrease access to food and drinks that are high in fats and sugars and low in nutrients. Having closed campus policies and limiting the number of vending machines in a school were a few steps to creating a healthier school environment (Neumark-Sztainer et al, 2005).

Kublik, Lytle, Hannan, Perry, and Story (2003) examined the variety of eating options and opportunities that today's students have and their dietary behaviors. Included in the study were government regulated nutrition programs, a la carte programs, school stores, and vending machines. Of the 16 schools examined, 90% had a la carte programs. Vending machines were

available in 76% of the high schools, 55% of the middle schools, and 15% of the elementary schools. School store type areas that sold food or drinks were found in 41% of the high schools, 35% of the middle schools, and 9% of the elementary schools.

Kublik et al. (2003) collected data from seventh grade students in 16 schools and assessed the influence of such things as fried potatoes being served at school lunch and the availability of a la carte programs and vending machines on students' consumption of fruits, vegetables, total fat, and saturated fat. All schools participated in the NSLP and were required to keep food production records, which included data on participating grades, the number of students served school lunch, and the quantity of food served. Schools were required to keep food production records because they were participants in the Teens Eating for Energy and Nutrition at School (TEENS) study. TEENS were a school-based dietary intervention trial created to promote healthful dietary behaviors to reduce future cancer risk. Trained nutritionists created school level variables representing the mean number of daily servings of fruits, vegetables, and fried potatoes, which were viewed separately from other vegetables. Trained nutritionists also observed school a la carte programs and recorded the number of items offered and sold to students. Grams of fat were recorded for snacks. A la carte foods were also categorized as either "food to promote", which included snacks containing less that 5 grams of fat per serving, 100% fruit juice, bottled water, 1% and skim milk, and lower-fat versions of high-fat foods and "foods to limit" that included all other snacks and sweetened drinks. A nutritionist looked at the availability of school stores and the location of vending machines that students were able to use. These items were categorized into three groups: "promote" and "limit," and "items that neither promote nor limit". The latter category included lower-fat candies, pastries, nuts, and diet drinks. Four thousand-fifty students were eligible to participate

in the study and 20% of those qualified for free or reduced lunch. Eight hundred forty-four students were selected from those who completed a 24-hour dietary recall interview. Kublik et al. (2003) examined the 24-hour dietary recall data and measured total fruit servings per day, total vegetable servings per day, and percentage of total energy from total fat and saturated fat.

Kublik et al. (2003) found school a la carte programs were significantly and negatively associated with total daily intake of fruits and of fruits and vegetables. Students from schools without a la carte programs consumed more than half a serving more of fruits per day than did students in schools with the a la carte program. Students not exposed to a la carte programs consumed, on average, almost an entire serving more of fruits and vegetables than students from schools with such programs. School a la carte programs were positively associated with students' mean percentage of daily calories obtained from total fat and saturated fat. Students who attended schools without a la carte programs reported a mean percentage of daily calories from total fat that met the USDA recommendations but students who attended schools with a la carte programs reported an excess of total fat. Both groups were found to exceed the recommended amount of saturated fat with students from schools without a la carte programs in excess by less than 0.5% and students with a la carte programs in excess by 1.5% of recommended daily intakes. Snack vending machines were negatively related to the average total daily servings of fruit eaten. Students' mean intake of fruit servings was found to be 11% less when snack vending machines were present at school. Fruit and vegetable intake and average total daily vegetable intake were positively associated with fried potatoes being served to students at school lunch. The data collected on beverage vending machines did not support and association between dietary fat intake and snack and beverage vending machines or fried potatoes being served to students at lunch.

The association between school a la carte programs and students' average daily consumption of fruits, fruits and vegetables, total fat, and saturated fat is significant. Students who were not exposed to the a la carte program reported intakes that met or came close to meeting USDA dietary recommendations. Students who had access to a la carte programs reported lower intakes of fruits and vegetables and a higher percentage of calories from total fat and saturated fat. Results also showed that high –fat snacks and calorie dense beverages were displacing fruits and vegetables and contributing to total fat and saturated fat intakes that exceed recommended levels. Findings indicate that a la carte items were disproportionately high-fat snacks and sweetened beverages (Kublik et al, 2003).

The number of snack vending machines in a school was negatively correlated with fruit consumption. The vast majority of vending machines held high-fat snacks. The more vending machines at school the more opportunity students had to purchase low-nutrient items. Results showed that students were choosing low-nutrient items instead of fruit (Kublik et al, 2003).

Kublik et al. (2003) report results that support the popularity of fried potatoes as a "preferred" vegetable choice by students who eat school lunch. Because of this preference school tended to offer fried potatoes as a daily lunch item. This offering was found to likely reinforce students' preference of high-fat foods.

This study examined and showed a negative association between physical factors in school food environment and students' consumption of fruits, vegetables, and dietary fat. Kublik et al.'s (2003) findings showed a need for school based intervention to promote healthy eating.

Today's students have been raised in an environment of fast food that is mostly eaten with their hands. Many meals that students consume are not cooked at home. They are purchased at restaurants, through carry out, or in some other capacity such as a school program. Meyer

(2005) conducted a study to determine which service characteristics affect the level of satisfaction that upper elementary students have with their foodservice and nutrition programs at school. These data were then used by food service professionals to improve their current school food programs.

Meyer's (2005) study was designed to determine the perception of school meals for third through fifth grade students. Meyer administered a survey of eighteen questions to measure characteristics of service. In addition, one question measured overall satisfaction, while eight questions concentrated on demographic information. The sample group totaled 537 students with 144 third graders, 145 fourth graders, and 232 fifth graders. Results showed that students were moderately satisfied with their school foodservice and nutrition programs overall, and with the factors of food quality and cafeteria. Students who are offered a choice of meals were more satisfied with school meals than those who didn't have a choice. Students were more satisfied with the service factor than with any other. Students in the "have a choice" group scored food quality and service higher than students in the "have no choice" group. Students who ate four or five times a week were more satisfied than students who ate less frequently. Third grade students were more satisfied than students in other grades, and the number one reason students identified for eating school lunch was that the food was good.

Students have been conditioned by eating away from home and are accustomed to the food choice and quality available at restaurants. Students want school meals to look and taste like the convenience of the fast food they eat outside of school. Students prefer to have a choice when making the decision to eat and what to eat. The students in this study were more satisfied overall and more pleased with the food quality when they perceived they had a choice about whether or not to eat school meals. Allowing students a choice with ala carte items is one method school

foodservice operations can use to provide students choices, but this makes it more difficult to ensure that students are meeting their daily nutrition requirements.

School foodservice and nutrition professionals face a difficult challenge when it comes to serving students a variety of foods that look appealing, taste good, and are served in a pleasant environment by a friendly staff. These challenges are ever changing as students grow because their wants, needs, and tastes change. Foodservice administrators can easily impact the menu to meet the need of providing variety to satisfy students. Other areas that administrators should be concerned with are taste and smell of food, brands offered, friendliness of staff, and time given to eat once students have been served their food. Monitoring these areas continuously, recognizing changes in student perception, and adapting their programs are other areas of concern. Increasing satisfaction and participation in the school foodservice program go together, and administrators must adapt their program to meet this ever changing environment (Meyer, 2005). Administrators are challenged to provide appealing meals while staying within budget constraints and adhering to USDA school meal regulations.

Clark and Fox (2009) assessed the nutritional quality of the diets of United States public school children and explored the relationship between students' participation in the school meal programs and the nutritional quality of their diets. This study was the third part of the School Nutrition Dietary Assessment Study (SNDA-III), a nationally representative study. Data were collected on 2,314 students in grades 1 through 12 from 287 public schools. Clark and Fox first sampled school food authorities, then schools served by these authorities, and then students who attended these schools. Students from these schools were randomly chosen to complete a 24-hour dietary recall and child interview. Parents of all sampled students were asked to complete a parent interview. The response rate for the 24-hour dietary recall and child interview was 63%,

and the response rate for the parent interview was 89% for those who completed the 24-hour dietary recall. Approximately 35% of the students were asked to complete a second dietary recall. The data collected was used in conjunction with the first data that had been gathered.

The nutritional quality of the children's diets was then assessed by estimating the inadequate and excessive intakes of energy and nutrients. Nutrient adequacy and excess were assessed by comparing usual intake distributions to Dietary Reference Intakes (DRI) and the Dietary Guidelines for Americans 2005. Results from this study show that most students attending United States public schools have adequate intakes of most vitamins and minerals, but their intakes of saturated fat, sodium, and total fat are excessive when compared to the DRIs and 2005 Dietary Guidelines. A group to be concerned about are high-school aged students. They were more likely to have excessive intakes of total fat and cholesterol along with inadequate intakes of several vitamins and minerals. Participation in school meal programs was linked to an increased likelihood of adequate vitamins and minerals, but also with an increased likelihood of excessive sodium intake.

Findings show the need to lower students' intakes of total fat, saturated fat, and sodium. To reach this goal will require changes in students' food consumption at school and away from school. Clark and Fox (2009) found that the fat and saturated fat content of school lunches was high when compared to DRIs and 2005 Dietary Guidelines. If the fat, saturated fat, and sodium content of school meals were decreased, it could have a tremendous effect on the overall fat and sodium content of students' diets. The leading sources of fat and sodium in the NSLP were the entrees. More than 40% of all entrees offered were commercially prepared and had excessive fat and sodium content (Crepinsek, et al. 2009). These foods may be convenient for the schools to use but at the cost of students' nutritional quality. Schools could improve on students' intake by

offering less ala carte options and limiting access to vending machines. Nutrition education may also lead to better informed food choices both inside and outside of school (Clark & Fox, 2009).

Sampson, Dixit, Meyers, and Houser (1995) found that not eating breakfast resulted in deficits in dietary intake of many essential nutrients. Sampson et al. examined the nutritional impact of breakfast consumption. Four elementary schools were chosen to participate in this study. Schools were chosen based on severe need status, having similar numbers of total students in the grades studied, and being located in comparable neighborhoods. One thousand one hundred seven children in the study qualified for free or reduced school meals. A self-administered eating behavior survey was given to the students on 4 random days over a two-week period. The survey contained four sections, one for each day, and asked two questions:

1. Did you have anything to eat before coming to school?

2. Did you eat a snack on the way to school?

Students were also asked to participate in a 24-hour dietary recall. They had to recall all of the foods eaten up to the time of the interview and also include all foods and beverages consumed from the time they left school on the previous day until they went to sleep. All questions were administered by an interviewer, so no reading was required by the student.

Their findings showed dietary adequacy is important for children with their proportionately greater nutrient requirement to sustain normal growth and development. Mild nutrient deficiencies can result in long term adverse effects on growth and function. An 80% participation rate of low income families in the National School Lunch Program (NSLP) suggests that decisions involving breakfast and dinner are of increased importance on school days. NSLP must provide one third of the recommended dietary allowances for essential nutrients. Students' cognitive function may be improved following a nutritious breakfast

compared to those students who skip breakfast. Nutrition lost by skipping breakfast may not necessarily be regained throughout the day.

Students were first classified into one of four categories: breakfast eaters, breakfast and snack eaters, snack-only eaters, and neither breakfast nor snack eaters. The mean age of breakfast skippers was 9.8 years old, and the mean age of the breakfast eaters was 9.3 years old. Median test comparisons of breakfast eaters with breakfast and snack eaters showed the two groups were comparable in nutrient intake at breakfast. The snack eaters were comparable for nutrient intake at breakfast with the neither breakfast nor snack eaters. The study looked at the recommended daily allowance (RDA) of the following nutrients: calories, fat, protein, percentage of calories from fat and cholesterol, vitamins A, D, E, C, B6, B12, thiamin, riboflavin, niacin, folacin, calcium, magnesium, iron, and sodium. Nutrient adequacy was defined as greater than or equal to 80% RDA and determined for each child using their 24-hour recall (Sampson et al., 1995).

Eighty-four percent to eighty-seven percent of the study sample responded to the survey. Twenty-two percent to twenty-six percent of students reported no eating breakfast before arriving at school. Seventy-one percent of students reported they ate before coming to school on all four survey days, four percent on none of the survey days, and 25% on one to three days. One the day of the dietary recall 79% of the study students reported eating only breakfast, 1.3% reported only eating a snack, and 8.2% reported eating both breakfast and a snack. Twelve percent reported eating nothing before school. The percentage of RDA provided by breakfast didn't differ for those students eating breakfast only compared with those eating both breakfast and a snack. Therefore, eating a snack didn't affect the nutritional content of breakfast, but it did contribute fat and calories to the diets of those who skipped breakfast and fat, iron, and thiamin

to those who ate breakfast. Fewer than 10% of all students failed to achieve dietary adequacy for intake of protein and vitamin B12. More than 40% consumed inadequate amounts of calories, vitamins A, E, B6, and calcium, and more than 90% didn't consume enough vitamin D. More than one third of breakfast skippers consumed less than 50% of RDA for vitamins A, E, B6, and folacin. Nearly one fourth consumed less than 50% of RDA for calories, vitamin C, calcium, and iron. Student who didn't eat breakfast consumed less daily sodium and cholesterol but a greater percentage of their daily calories from fat than students who ate breakfast. Breakfast skippers were below the recommended limit for daily cholesterol intake but about the recommend daily percentage of calories from fat (Sampson et al., 1995).

Students who ate breakfast were more likely than those who skipped breakfast to achieve dietary adequacy for calories, protein, vitamins A, B6, C, D, E, thiamin, riboflavin, niacin, folacin, calcium, magnesium, and iron. Morning cognitive test performance of well-nourished students was significantly better in the fed state than in the fasted state. For students who skipped breakfast, nearly three fourths failed to consume greater than or equal to 80% of the RDA for energy, and one fourth of those students consumed less than 50% RDA. Breakfast skipping contributed to similar deficits in iron and calcium. Iron deficiencies are of special concern because of its impact on cognitive function in children (Sampson et al., 1995).

Chapter III

Results and Analysis Relative to Problem

Good nutrition is important to supporting growth and maximizing learning potential. Due to current research, we are becoming increasingly educated on the role nutrition plays on the body's and mind's ability to grow and the performance of our potential learning capacity. Nutritional intake affects energy levels, physical stamina, mood, memory, mental clarity, and emotional and mental well-being. Research is proving good nutrition is pertinent for the brain, so the old adage, "You are what you eat" is proving to be true. Parents and educators need to educate today's youth to make healthier food choices because they are being raised in a culture of fast food (Meyer, 2005). Because today's children are being raised during a time when many meals are not being prepared at home, America is seeing the negative outcomes of poor nutritional choices.

Americans eat an excessive amount of total fat, saturated fat, and cholesterol which contributes to health problems that are causing health organizations and federal agencies to endorse the fat restrictions recommended by US Dietary Guidelines. High intakes of PUFAS contributed to better performance on the digit span test, but on the other hand an increased intake of cholesterol may have been associated with a poorer performance (Zhang et al., 2005). Researchers also found an association with decreased visuospatial organization and mental ability with increased body weight (Li et al., 2008) as well as a correlation between iron deficiencies and lower standardized math test scores (Halterman et al., 2001). PEM was found to affect the continuous development of higher cognitive functioning during childhood (Kar et al., 2008).

Elementary students that have a positive perception of school meals tend to be more satisfied with the school foodservice and nutrition program; therefore they are more likely to participate in the school food program (Meyer, 2005). As student progress their tastes change and to keep up with those changes the school food environment tends to become increasingly less healthy (Finkelstein et al., 2008). These less healthy choices are more options for food opportunities that compete with the main lunch line that provides healthier options. The majority of US high schools sell competitive food items in the cafeteria through vending machines, a la carte lines, or school stores. School policies might also allow students to leave campus during lunch time. Competitive foods are often low-nutrient, high-density foods and drinks. School food policies that limit access to these types of foods and beverages have fewer purchases and thus less consumption of these types of unhealthy items (Neumark-Sztainer et al., 2005). These limitations reduce the opportunities students have to consume food and beverages filled with empty calories. School-based programs that aim to promote healthy eating among students should target lowering the number of places and limiting the hours in which students have access to unhealthy food and drink purchases (Kublik et al., 2003).

Providing quality food that is appealing to students will help promote healthy eating among students as will limiting students' access to low-nutrient, high-energy foods. School meal programs play an important role in the nutritional adequacy of students' diets. Dietary adequacy is of the utmost importance for students with their nutrient requirements to sustain normal growth and development. Even mild nutrient deficiencies can end with negative long-term effects on growth and function (Sampson et al., 1995).

New research on the ramifications of food insecurity on various aspects of child health, such as academic achievement and psychological behavior, demonstrated that it is an important

risk factor in child development. Food insufficiency and low socioeconomic status are health concerns for American children (Alaimo et al., 2001) because they have been linked with certain developmental consequences (Jyoti et al., 2005). One of the possible outcomes of food insufficiency and low socioeconomic status is increase in BMI. Overweight and obese children were found to have an increased instance of medical and psychological issues. They were also found to be absent from school more often than normal-weight children (Geier et al., 2007). Lower scholastic achievement, socially unacceptable behavior, and poorer physical fitness were also attributed to food insufficiency (Shore et al., 2008). Shore et al. stressed the need for healthy lifestyle intervention and prevention measures to help students work to their full potential.

Chapter IV

Recommendations and Conclusion

Research increasingly supports the important link between nutrition and learning potential. Healthy eating is essential for students to achieve their full academic potential, mental growth, and lifelong health and well-being. When children are not receiving proper nutrition they are unable to reach their full potential. Schools need to educate parents and children on how to live a healthy lifestyle that includes proper nutrition. Schools can help school-aged children develop healthy eating habits by emitting a consistent health message by ensuring that healthy food choices are offered at school. School administrators need to provide opportunities for staffs to receive education on good nutrition and health in the school environment. Schools should establish committees that include parents and community members to promote a healthy school atmosphere by focusing on nutrition and vending policies.

Schools need to make the commitment to offer quality meals that provide the energy and nutrients students need to achieve their maximum potential. Many schools sell low-nutrient, energy-dense items through a la carte in the cafeteria and vending machines. Due to budget cuts schools have come to rely on the profits made through these venues. Unfortunately, federal regulations do not apply to competitive food offerings, items that are not part of the reimbursable USDA meals (Finkelstein et al., 2008), so until school policy addresses this issue there will continue to be unhealthy foods available in the school environment. By offering a variety of healthy foods in the school meal program children will learn to enjoy many different foods and develop healthy eating habits. Schools can show they are committed by ensuring that food staff is properly trained, and the menu meets or exceeds the nutrition standards set forth by the USDA. Students should be asked for their input before planning school meals so that a variety of food

can be offered that is not only nutritious but appealing to the students. One way to appeal to students is to get them involved with hands-on experience in producing some of their own food.

Ratcliffe, Merrigan, Rogers, and Goldberg (2009) investigated the impact of participating in a school garden program. They analyzed the students' ability to identify, willingness to try, preference for, and overall consumption of vegetables. Ratcliffe et al. found many positive connections with the program. Students who participated in the hands-on program were better able to identify vegetables and their preference for vegetables increased significantly ($p = 0.029$). Students who participated in the program were willing to taste a variety of vegetables including those types that weren't grown in the school garden. Consumption of vegetable varieties during school also increased. Unfortunately, it was not known if the garden-based learning experience increased the number of vegetable servings that students actually ate or if it made them healthier.

Schools need to offer only foods that promote a healthy school environment. Offering high-energy, low-nutrient food in vending machines, a la carte lines, or school stores allows for competition with healthy food offerings. This competition needs to be eliminated by offering only foods and beverages that contribute to meeting the dietary needs of students. Snack choices should be made based on meeting students' dietary needs and not on profits. Parents who send bag lunches for their children should be encouraged to send nutritious food that provides a healthy meal. Parent Nutrition newsletters could be sent home with sample menus and up-to-date nutrition information to help parents make good food choices for their student. To stay consistent with offering healthy foods, parties, fund-raisers, and concession stands should also have guidelines that adhere to the healthy food message that the school will promote.

Meals should be served in a comfortable, friendly atmosphere. Since environment does play a role in students' eating behaviors, students may be more apt to eat a healthy meal if they

have enough time to eat, relax, and converse with their friends. Making the cafeteria pleasing to the eye and having pleasant food service workers can appeal to the overall sense of ease and encouragement of consuming a healthy meal.

Nutrition education makes a difference in making healthy eating choices. Students at all levels should receive nutrition education that will teach them the skills to make healthy choices not only at school but at home as well. Families should also receive nutrition bulletins throughout the school year to help them reinforce what is being learned at school.

Making healthy food choices available to students is important as is educating students, parents, teachers, food service staff, administrators, and the community. Schools need to promote a healthy eating environment and seek out student input to be used when planning a healthy menu. The goal is to meet the dietary needs so that students are able to reach their potential physically and cognitively.

Due to the considerable amount of time children spend at school more attention needs to be paid to the food options that are available if we want healthy eating to become a normal lifelong behavior. Schools can't ignore the importance of supporting healthy habits since about 35% of a student's daily calories are consumed at school (Neumark-Sztainer et al., 2005). More research needs to be done to gather more information to show a correlation between nutrition and cognitive function and academic performance.

A growing data base of scientific research suggests that certain food modules may affect the danger of decreased brain function and chronic disease. Studies could be done to further assess the relationship between foods and health outcomes. A study should be conducted in a school setting to show the direct relationship between meeting the recommended daily allowance (RDA) of various food groups such as fruits, vegetables, meat, and grains on the effects of

cognitive function and academic performance. This investigation could use a longitudinal data set that follows a random sampling of children from kindergarten through the end of their primary education. Detailed health and nutrition data could be gathered every few months by interview and 24-hour recall. Students could be categorized into those who meet the RDA, those who sometimes meet RDA, and those who don't. Analyzing students' standardized test scores should give a picture of their academic performance. Observing the same sampling of students over a long period of time should make a strong argument for the correlation adequate nutrition and its effects on cognitive function and academic performance. Results could also be used to look at the diets of the students with higher performance to see what their diets consist of and suggestions could be made to the USDA to help strengthen their guidelines for school meals. One Limitation to this study would be that students are not a true random selection, because only the participating districts would be random. The number of students in the study is limited to the number of students in the participating district for each grade level. Another study could determine the obstacles that don't allow certain groups like low-income families and ethnic groups to follow healthy eating plans. Ways to educate and motivate these groups could be designed to help them achieve a better life physically and cognitively. Strategies to aid families in working toward meeting dietary guidelines but remaining at a healthy weight might also be an outcome of such a trial. Further research could look at the correlation between food patterns, such as snacking and meal skipping, and BMI, obesity. By studying the effects of food patterns we can better understand how to manage our body weight, which will lead to positively supporting our health as a whole.

A school is an institution of education and research supports the role nutrition plays in education. This relationship supports the idea that schools have a vital role in providing students

with healthy eating opportunities and the tools to make healthy choices no matter where they are. Intense pressure has been placed on schools to have students demonstrate high performance on state mandated test and nutrition plays a key role in this success. Nutrition should be taken off the back-burner and place front and center to help students reach their full learning potential. Our goal must be to teach all children the meaning and importance of good nutrition so they are able to develop good eating habits that will support a lifetime of maximizing their full potential.

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