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Nutrition, Learning and Behavior in Children: A Resource List for Professionals

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This Food and Nutrition Information Center (FNIC) Resource List is a quick guide designed to help professionals find information related to nutrition, learning and behavior in children. Opinions expressed in the publications do not necessarily reflect the views of the U.S. Department of Agriculture.

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I. **General Nutrition, Hunger, Learning and Behavior in the United States**

A. **Articles Dated 2000 - Present**

Behavioral and cognitive status in school-aged children with a history of failure to thrive during early childhood. R.A. Dykman, et al. *Clinical Pediatrics*, 40(2): 63-70. 2001.

NAL Call Number: RJ1-C55

Abstract: Twenty-seven school children (aged 8-12 years) earlier diagnosed with nonorganic failure to thrive (FTT) were compared with a normal socioeconomically matched control group (N=17) on current height and weight parameters as well as cognitive, achievement, and behavioral measures from the Child Behavior Checklist (CBCL). The former FTT children were, on average, smaller, less cognitively able, and more behaviorally disturbed than the control children and national normative samples. Sixty percent of former FTT children were below the 20th percentile in height and 48% were below the 20th percentile in weight; 52% had IQs below 80 and 30% had reading standard scores below 80; 48% had clinically adverse attention ratings and 30% had clinically adverse aggression ratings on the CBCL. Within the FTT sample, however, there were no significant associations between current growth measures and cognitive/achievement outcome measures. Mothers' IQs provided the strongest prediction of the FTT children's reading scores. The mothers of the FTT children had not achieved as high levels of education as the mothers of the control children, and more of them were single parents. Early growth problems put children at high risk for multiple adverse sequelae in middle childhood, especially if mothers are poorly educated. Careful ongoing follow-up of such children by pediatricians is encouraged.

Breakfast and Performance. S. Cueto. *Public Health Nutrition*, 4(6A): 1429-31. 2001.

NAL Call Number: RA784-P83

Description: This review article summarizes information from empirical sources about the effect of

breakfast consumption on energy availability, nutritional status, school attendance and performance. Evidence suggests that the effect of fasting on performance is not uniform, but it is dependent on the basal nutritional status of the subject. Breakfast consumption has a short-term effect in improving selected learning skills, especially work memory. School breakfast programs have a positive effect on the nutritional status of children, on school attendance and probably on dropout rates. The effect of breakfast consumption on school performance depends on the interaction between the program, student characteristics (malnutrition) and school organization. Unless the school setting guarantees a minimum quality standard, the benefits of breakfast consumption will not be evident in performance in complex areas like language or math.

Effects of growth restriction in early childhood on growth, IQ, and cognition at age 11 to 12 years and the benefits of nutritional supplementation and psychosocial stimulation. S.P Walker, et al.

Journal of Pediatrics, 137(1): 36-41. 2000.

NAL Call Number: RJ1-A453

Abstract: The objectives of this study were 1) to determine whether benefits to growth and cognition remain after intervention in growth-restricted children who received psychosocial stimulation and nutritional supplementation in early childhood, and 2) to investigate the extent of the differences in IQ and cognition at age 11 to 12 years between growth restricted and non-growth restricted children. Growth restricted and non-growth restricted children were identified at age 9 to 24 months, at which time the growth restricted children participated in a 2-year randomized trial of nutritional supplementation and psychosocial stimulation. Eight years after the interventions ended, the children's growth, IQ, and cognitive functions were measured. There were no significant benefits from supplementation to growth or cognition. Children who had received stimulation had higher scores on the Weschler Intelligence Scales for Children-Revised full-scale (IQ) and verbal scale and tests of vocabulary and reasoning (all $P < 0.05$). The growth restricted children had significantly lower scores than the non-growth restricted children on 10 of 11 cognitive tests. Psychosocial stimulation had small but significant long-term benefits on cognition in growth-restricted children. Growth restricted children had significantly poorer performance than non-growth restricted children on a wide range of cognitive tests, supporting the conclusion that growth restriction has long-term functional consequences.

Food insufficiency and American school-aged children's cognitive, academic, and psychosocial development. K. Alaimo, C.M. Olson, and E.A. Frongillo Jr. *Pediatrics*, 108(1): 44-53. 2001.

NAL Call Number: RJ1-P42

Abstract: This study investigates associations between food insufficiency and cognitive, academic, and psychosocial outcomes for US children and teenagers ages 6 to 11 and 12 to 16 years. Data from the Third National Health and Nutrition Examination Survey (NHANES III) were analyzed. Children were classified as food-insufficient if the family respondent reported that his or her family sometimes or often did not get enough food to eat. Regression analyses were conducted to test for associations between food insufficiency and cognitive, academic, and psychosocial measures in general and then within lower-risk and higher-risk groups. Regression coefficients and odds ratios for food insufficiency are reported, adjusted for poverty status and other potential confounding factors. After adjusting for confounding variables, 6- to 11-year-old food-insufficient children had significantly lower arithmetic scores and were more likely to have repeated a grade, have seen a psychologist, and have had difficulty getting along

with other children. Food-insufficient teenagers were more likely to have seen a psychologist, have been suspended from school, and have had difficulty getting along with other children. Further analyses divided children into lower-risk and higher-risk groups. The associations between food insufficiency and children's outcomes varied by level of risk. The results demonstrate that negative academic and psychosocial outcomes are associated with family-level food insufficiency and provide support for public health efforts to increase the food security of American families.

Nutritional deficiencies and later behavioural development. S.M. Grantham McGregor, S.P. Walker, S. Chang. *Proceedings of the Nutrition Society*, 59(1): 47-54. 2000.

NAL Call Number: 389.9-N953

Description: The literature on the long term effects of nutritional deficiencies in early life is reviewed. The severity and duration of the deficiency, the stage of the children's development, the biological condition of the children and the socio-cultural context may all modify the effect. There is substantial evidence that reduced breast feeding, small for gestational age birth weight, Fe and I deficiency, and protein energy malnutrition (PEM) are associated with long term deficits in cognition and school achievement. However, all these conditions are associated with poverty and poor health, which may account for the association. It is difficult to establish that the long term relationship is causal, as it requires a randomized treatment trial with long term follow up. Such studies are only available for I deficiency in utero and early childhood PEM. Results from these studies indicate that I deficiency has a long term effect and PEM probably has a long term effect.

Nutritional influences on cognitive function: mechanisms of susceptibility. E.L. Gibson and M.W. Green. *Nutrition Research Reviews*, 15(1): 169-206. 2002.

NAL Call Number: QP141.A1N87

Description: The impact of nutritional variation, within populations not overtly malnourished, on cognitive function and arousal is considered. The emphasis is on susceptibility to acute effects of meals and glucose loads, and chronic effects of dieting, on mental performance, and effects of cholesterol and vitamin levels on cognitive impairment. New developments in understanding dietary influences on neurohormonal systems, and their implications for cognition and affect, allow reinterpretation of both earlier and recent findings. Evidence for a detrimental effect of omitting a meal on cognitive performance remains equivocal: from the outset, idiosyncrasy has prevailed. Yet, for young and nutritionally vulnerable children, breakfast is more likely to benefit than hinder performance. For nutrient composition, despite inconsistencies, some cautious predictions can be made. Acutely, carbohydrate-rich-protein-poor meals can be sedating and anxiolytic; by comparison, protein-rich meals may be arousing, improving reaction time but also increasing unfocused vigilance. Fat-rich meals can lead to a decline in alertness, especially where they differ from habitual fat intake. These acute effects may vary with time of day and nutritional status. Chronically, protein-rich diets have been associated with decreased positive and increased negative affect relative to carbohydrate-rich diets. Probable mechanisms include diet-induced changes in monoamine, especially serotonergic neurotransmitter activity, and functioning of the hypothalamic-pituitary-adrenal axis. Effects are interpreted in the context of individual traits and susceptibility to challenging, even stressful, tests of performance. Preoccupation with dieting may impair cognition by interfering with working memory capacity, independently of nutritional status. The change in cognitive performance after administration of glucose, and other foods,

may depend on the level of sympathetic activation, glucocorticoid secretion, and pancreatic β -cell function, rather than simple fuelling of neural activity. Thus, outcomes can be predicted by vulnerability in coping with stressful challenges, interacting with nutritional history and neuroendocrine status. Functioning of such systems may be susceptible to dietary influences on neural membrane fluidity, and vitamin-dependent cerebrovascular health, with cognitive vulnerability increasing with age.

B. Articles Dated Prior to 2000

Breakfast and cognition: an integrative summary. E. Pollitt and R. Mathews. *American Journal of Clinical Nutrition*, 67(4): 804S-812S. 1998.

NAL Call Number: 389.8 J824

Description: In this supplement, the papers presented at the International Symposium on Breakfast and Performance in Napa, CA in 1995 are summarized and integrated with data published since that time. The papers report on research conducted in the United States and abroad, conducted on adults and children. In particular, the focus is on issues of research design, measurements, mechanisms, potential effect modifiers (eg. age), and relevance for public policy. No definitive conclusions can be drawn from the existing data on either the long and short term benefits of breakfast on cognition and school learning or the mechanisms that mediate this relation. The pooled data suggest that omitting breakfast interferes with cognition and learning, an effect that is more pronounced in nutritionally at risk children than in well nourished children. At the very least, breakfast consumption improves school attendance and enhances the quality of the students' diets.

Diet and adolescent behavior: is there a relationship? M. Story and D. Neumark Sztainer. *Adolescent Medicine*, 9(2): 283-98. 1998.

Description: Behavioral problems such as hyperactivity, learning disabilities, mental illness, aggressive and antisocial behavior, and juvenile delinquency have been purportedly linked to the potential influence of foods or nutrients. This article examines the scientific evidence of the relationship between food and behavior in children and adolescents. It highlights the implications for practitioners important to consider in the assessment of the relationship between diet and behavior.

The effect of sugar on behavior or cognition in children: a meta-analysis. M.L. Wolraich, D.B. Wilson, and W. Wade. *Journal of the American Medical Association*, 274(20): 1617-1621. 1995.

NAL Call Number: 448.9-Am37

Abstract: The objective of this paper was to examine the effects of sugar on the behavior or cognition of children by using meta-analytic techniques on reported studies. Studies were identified through a literature search of the MEDLINE and PsychINFO databases and the authors' files using sugar, sucrose, and attention deficit disorder as the search terms. Studies were required to (1) intervene by having the subjects consume a known quantity of sugar; (2) use a placebo (artificial sweetener) condition; (3) blind the subjects, parents, and research staff to the conditions; and (4) report statistics that could be used to compute the dependent measures effect sizes. The meta-analytic synthesis of the studies to date found that sugar does not affect the behavior or cognitive performance of children. The strong belief of parents may be due to expectancy and common association. However, a small effect of sugar or effects on subsets of children cannot be ruled out.

Effects of diets high in sucrose or aspartame on the behavior and cognitive performance of children. M.L. Wolraich, et al. *The New England Journal of Medicine*, 330(5): 301-307. 1994. NAL Call Number: 448.8-N442

Abstract: Both dietary sucrose and the sweetener aspartame have been reported to produce hyperactivity and other behavioral problems in children. This study conducted a double-blind controlled trial with two groups of children: 25 normal preschool children (3 to 5 years of age), and 23 school-age children (6 to 10 years) described by their parents as sensitive to sugar. The children and their families followed a different diet for each of three consecutive three-week periods. One diet was high in sucrose with no artificial sweeteners, another was low in sucrose and contained aspartame as a sweetener, and the third was low in sucrose and contained saccharin (placebo) as a sweetener. All the diets were essentially free of additives, artificial food coloring, and preservatives. The children's behavior and cognitive performance were evaluated weekly. Results indicated that the preschool children ingested a mean (+/- SD) of 5600 +/- 2100 mg of sucrose per kilogram of body weight per day while on the sucrose diet, 38 +/- 13 mg of aspartame per kilogram per day while on the aspartame diet, and 12 +/- 4.5 mg of saccharin per kilogram per day while on the saccharin diet. The school-age children considered to be sensitive to sugar ingested 4500 +/- 1200 mg of sucrose per kilogram, 32 +/- 8.9 mg of aspartame per kilogram, and 9.9 +/- 3.9 mg of saccharin per kilogram, respectively. For the children described as sugar-sensitive, there were no significant differences among the three diets in any of 39 behavioral and cognitive variables. For the preschool children, only 4 of the 31 measures differed significantly among the three diets, and there was no consistent pattern in the differences that were observed. It was concluded that even when intake exceeds typical dietary levels, neither dietary sucrose nor aspartame affects children's behavior or cognitive function.

Effects of breakfast size on short term memory, concentration, mood and blood glucose.

C. Michaud, et al. *Journal of Adolescence Health*, 12(1): 53 57. 1991.

Abstract: Effects of breakfast size on blood glucose, mood, short term memory and concentration were assessed in 319 adolescents (age 13 20 years) in a real life setting. Mean energy increase of 63% over habitual breakfast had no effect on blood glucose or late morning mood. High energy intake from breakfast had a beneficial effect on immediate recall in short term memory evaluated on the whole sample. However, concentration appeared to be impaired by a high caloric breakfast. There were no differences in the studied parameters according to energy supplement size. The present results are consistent with suggestions that meal size supplement has an effect on cognitive function.

Effects of breakfast and caffeine on cognitive performance, mood and cardiovascular functioning.

A. Smith, et al. *Appetite*, 22(1): 39 55. 1994.

NAL Call Number: QP141-A1A64

Abstract: Two experiments examined the effect of breakfast (1.89 MJ) and caffeine (4 mg/kg) on cognitive performance, mood and cardiovascular functioning in children. In the first experiment, breakfast had no effect on performance of sustained attention tasks, but it increased pulse rate and influenced mood. The mood effects after breakfast differed between a cooked breakfast and a cereal/toast breakfast. In contrast to the effects of breakfast, this relatively high dose of caffeine improved performance of the sustained attention tasks, increased blood pressure and increased mental alertness. In

the second experiment, effects of a breakfast and caffeine on mood and cardiovascular functions confirmed the results of the first study. The breakfast improved performance on free recall and recognition memory tasks, had no effect on a semantic memory task and impaired the accuracy of performing a logical reasoning task. In contrast to this, caffeine improved performance on the semantic memory, logical reasoning, free recall and recognition memory tasks. Overall, these results show that breakfast can improve performance in some but not all cognitive tasks and that these changes are very different from those observed after lunch, and those produced by caffeine.

Fasting and cognition in well and undernourished schoolchildren: a review of three experimental studies. E. Pollitt, S. Cueto, E.R. Jacoby. *American Journal of Clinical Nutrition*, 67(4): 779S-784S. 1998.

NAL Call Number: 389.8 J824

Description: This paper reviews three experiments on the effects of an overnight and morning fast on attention and memory processes among 9-11 year old children. Two of the experiments focused on middle class, well nourished boys and girls in the United States; the third involved boys from low income families with and without nutritional risk in Huaraz, Peru. All experiments used the same crossover design and followed similar experimental procedures to control the subjects' intakes and motor activity during the study period. The children were admitted to a research center on two different evenings, approximately 7 d apart. After arrival the children ate dinner, played table games or watched television, and went to bed. They were awakened at 0730 and, by design, were either served breakfast (approximately 2301 kJ) or not. At 1100 they took psychologic tests that assessed recall from working memory and competence in discriminating visual stimuli. At 1200 the children were discharged. The consequences of the overnight and morning fast, particularly among the children who were nutritionally at risk, included slower stimulus discrimination, increased errors, and slower memory recall. We propose that these alterations result from a state of metabolic stress in which homeostatic mechanisms work to maintain circulating glucose concentrations.

Hunger in children in the United States: potential behavioral and emotional correlates. R.E. Kleinman. *Pediatrics*, 101(1): E3. 1998.

NAL Call Number: RJ1-P42

Description: Results from a recent series of surveys from 9 states and the District of Columbia by the Community Childhood Hunger Identification Project (CCHIP) provide an estimate that 4 million American children experience prolonged periodic food insufficiency and hunger each year, 8% of the children under the age of 12 in this country. The same studies show that an additional 10 million children are at risk for hunger. The current study examined the relationship between hunger as defined by the CCHIP measure (food insufficiency attributable to constrained resources) and variables reflecting the psychosocial functioning of low income, school aged children. The study group included 328 parents and children from a CCHIP study of families with at least 1 child under the age of 12 years living in the city of Pittsburgh and the surrounding Allegheny County. A two stage area probability sampling design with standard cluster techniques was used. All parents whose child was between the ages of 6 and 12 years at the time of interview were asked to complete a Pediatric Symptom Checklist, a brief parent report questionnaire that assesses children's emotional and behavioral symptoms. Hunger status was defined by parent responses to the standard 8 food insufficiency questions from the CCHIP survey that

are used to classify households and children as "hungry," "at risk for hunger," or "not hungry." In an area probability sample of low income families, those defined as hungry on the CCHIP measure were significantly more likely to have clinical levels of psychosocial dysfunction on the Pediatric Symptom Checklist than children defined as at risk for hunger or not hungry. Analysis of individual items and factor scores on the Pediatric Symptom Checklist showed that virtually all behavioral, emotional, and academic problems were more prevalent in hungry children, but that aggression and anxiety had the strongest degree of association with experiences of hunger. Children from families that report multiple experiences of food insufficiency and hunger are more likely to show behavioral, emotional, and academic problems on a standardized measure of psychosocial dysfunction than children from the same low income communities whose families do not report experiences of hunger. Although causality cannot be determined from a cross sectional design, the strength of these findings suggests the importance of greater awareness on the part of health care providers and public health officials of the role of food insufficiency and hunger in the lives of poor children.

Malnutrition, brain development, learning, and behavior. N.S. Scrimshaw. *Nutrition Research*, 18 (2): 351-379. 1998.

NAL Call Number: QP141-A1N88

Description: Three widely prevalent nutritional deficiencies are recognized to have the potential for permanent adverse effects on learning and behavior: protein energy, iron, and iodine. Supplementation with adequate protein and calories during the first two years of life improves the cognitive performance of poorly nourished children, and the benefits may be even more robust years later when the children become adolescents and young adults. Iron deficiency is the most common global nutritional problem; among the earliest functions to be affected are those associated with the brain enzymes involved in cognition and behavior. The effects of iron deficiency during infancy appear to be irreversible. At older ages iron deficiency is intellectually and educationally disadvantageous independently of ethnicity and of physical and social environment. Even in areas where cases of cretinism due to iodine deficiency in the mother are few, the linear growth of the infant, its intellectual capacity, and certain other of its neurological functions are permanently compromised to varying degrees. In addition to these three most prevalent forms of deficiency, recent evidence suggests that cow's milk and infant formulas may lack sufficient omega 3 fatty acids for optimal development of the preterm infant and the neonate. Nutritional deficiencies are also potential contributors to impaired cognition in the elderly. Investments in education and community development would be more effective if the physical and cognitive capacity of underprivileged populations were not impaired by malnutrition.

Nutrition and health outcomes associated with food insecurity and hunger. C.M Olson. *Journal of Nutrition*, 129(2S): 521S-524S. 1999.

NAL Call Number: 389.8-J82

Abstract: This paper explores how food insecurity and hunger relate to health and nutrition outcomes in food rich countries such as the United States. It focuses on two subgroups of the population for whom data are available: women of childbearing age and school age children. Special consideration is given to examining how food insecurity relates to these outcomes independently of socioeconomic status and poverty. In a population based sample of women of childbearing age, the least severe level of food insecurity (household food insecurity) was correlated with higher body mass index (BMI), controlling

for other available and known influences on obesity including income level. In low income school age children from two large urban areas of the U.S., risk of hunger and hunger were associated with compromised psychosocial functioning, controlling for maternal education and estimated household income. The nutrition and health consequences of food insecurity comprise a potentially rich area for future, socially relevant research in the field of nutritional sciences

Psychological effects of snacks and altered meal frequency. R. Kanarek. *British Journal of Nutrition*, 77(Suppl 1): S105 18; discussion 118 20. 1997.

NAL Call Number: QP141.A1N87

Description: Over the past two decades, substantial research has been conducted to investigate the idea that alterations in short term nutritional intake play a role in influencing cognitive behavior and mood. A portion of this research has examined specifically the effect of meal intake on the performance of mental tasks and subjective feelings of mood. Results of this research indicate that a number of variables including the timing and nutritional composition of the meal, nutritional status, habitual patterns of feeding behavior, beliefs about food, and the nature of the mental tasks, can influence the effects of meals on cognitive behavior. For example, studies have demonstrated that breakfast intake generally is associated with an improvement in cognitive performance later in the morning, while lunch intake is associated with an impairment in mid afternoon performance on mental tasks and more negative reports of mood. Intake of nutrients late in the afternoon appears to have a positive effect on subsequent performance on tasks involving sustained attention or memory. Although research has provided insights into the role of meal intake on cognitive behavior and mood, there are a number of factors which remain to be studied. These include the interaction of age, gender, activity level, meal composition, personality factors, stress with the effects of meals on cognitive behavior. Additionally, more work is needed on the time course of short term nutrient effects, and the effects of chronic changes in meal intake on behavior.

Relationship between hunger and psychosocial functioning in low income American children. J.M. Murphy, et al. *Journal of American Academic Child Adolescence Psychiatry*, 37(2): 163 70. 1998.

Abstract: Using large scale surveys from nine states, the Community Childhood Hunger Identification Project (CCHIP) estimates that 8% of American children under the age of 12 years experience hunger each year. CCHIP operationalizes child hunger as multiple experiences of parent reported food insufficiency due to constrained resources. The current study examined the relationship between food insufficiency and school age, low income children's psychosocial functioning. The study also assessed the interinformant (parent versus child) reliability and time to time reliability of the CCHIP measure. Two hundred four school age children and their parents from four inner city public schools were interviewed using parent, teacher, and clinician report measures of psychosocial functioning. Ninety six children and their parents were re-interviewed 4 months later. Hungry and at risk for hunger children were twice as likely as not hungry children to be classified as having impaired functioning by parent and child report. Teachers reported higher levels of hyperactivity, absenteeism, and tardiness among hungry/at risk children than not hungry children. Parent and child reports of hunger were significantly related to each other, and time to time reliability of the CCHIP measure was acceptable. Results of this study suggest that intermittent experiences of food insufficiency and hunger as measured by CCHIP are associated with poor behavioral and academic functioning in low income children. The current study also supports the validity and reliability of the CCHIP measure for assessing hunger in children.

The role of diet and behaviour in childhood. J. Breakey. *Journal of Pediatrics and Child Health*, 33 (3): 190-194. 1997.

Description: This short review summarizes the most important research, particularly that from 1985 to 1995, on the relationship between diet and behavior. Relevant studies particularly those using double-blind placebo-controlled food challenge methodology were selected, and are presented within a historical context. Summary tables of the early development of concepts and later pertinent studies are provided. The research has shown that diet definitely affects some children. Rather than becoming simpler the issue has become demonstrably more complex. The range of suspect food items has broadened, and some nonfood items are relevant. Symptoms which may change include those seen in attention deficit disorder (ADD) and attention deficit hyperactivity disorder (ADHD), sleep problems and physical symptoms, with later research emphasizing particularly changes in mood. The reports also show the range of individual differences both in the food substances producing reactions and in the areas of change.

The role of nutrition in the development of normal cognition. N. Kretchmer, J.L. Beard, and S. Carlson. *American Journal of Clinical Nutrition*, 63(6): 997S-1001S. 1996.

NAL Call Number: 389.8 J824

Description: The goal of this paper was to review the relation between nutrition and cognition. The topics selected for discussion included generalized malnutrition, iodine deficiency, iron metabolism, and the relation of fatty acids to the development of the nervous system. These short essays provide insight into the status of our current knowledge.

II. Micronutrient Status, Learning and Behavior in the United States

A. Articles Dated 2000 - Present

A randomized double-blind, placebo-controlled study of the effects of supplementation with highly unsaturated fatty acids on ADHD-related symptoms in children with specific learning difficulties.

A.J. Richardson and B.K. Puri. *Progress in Neuropsychopharmacology and Biological Psychiatry*, 26 (2): 233-9. 2002.

Abstract: The authors tested the prediction that relative deficiencies in highly unsaturated fatty acids (HUFAs) may underlie some of the behavioral and learning problems associated with attention-deficit/hyperactivity disorder (ADHD) by studying the effects of HUFA supplementation on ADHD-related symptoms in children with specific learning difficulties (mainly dyslexia) who also showed ADHD features. Forty-one children aged 8-12 years with both specific learning difficulties and above-average ADHD ratings were randomly allocated to HUFA supplementation or placebo for 12 weeks. At both baseline and follow-up, a range of behavioral and learning problems associated with ADHD was assessed using standardized parent rating scales. At baseline, the groups did not differ, but after 12 weeks mean scores for cognitive problems and general behavior problems were significantly lower for the group treated with HUFA than for the placebo group; there were significant improvements from

baseline on 7 out of 14 scales for active treatment, compared with none for placebo. Group differences in change scores all favored HUFA, reaching conventional significance levels for 3 out of 14 scales. HUFA supplementation appears to reduce ADHD-related symptoms in children with specific learning difficulties. Given the safety and tolerability of this simple treatment, results from this pilot study strongly support the case for further investigations.

A review of studies on the effect of iron deficiency on cognitive development in children. S.

Grantham-McGregor and C. Ani. *Journal of Nutrition*, 131(2S-2): 649S-666S; discussion 666S-668S. 2001.

NAL Call Number: 389.8 J82

Description: Studies on the effect of iron deficiency on children's cognition and behavior are selectively reviewed, looking for evidence of a causal relationship. Most correlational studies have found associations between iron-deficiency anemia and poor cognitive and motor development and behavioral problems. Longitudinal studies consistently indicate that children anemic in infancy continue to have poorer cognition, school achievement, and more behavior problems into middle childhood. However, the possible confounding effects of poor socioeconomic backgrounds prevent causal inferences from being made. In anemic children <2 y old, short-term trials of iron treatment have generally failed to benefit development. Most longer trials lacked randomized placebo groups and failed to produce benefits. Only one small randomized controlled trial (RCT) has shown clear benefits. It therefore remains uncertain whether the poor development of iron-deficient infants is due to poor social backgrounds or irreversible damage or is remediable with iron treatment. Similarly, the few preventive trials have had design problems or produced no or questionable benefits only. For children >2 y old, the evidence from RCT is reasonably convincing but not conclusive. RCT of iron treatment are warranted especially in younger children.

Iron deficiency and cognitive achievement among school-aged children and adolescents in the United States. J.S. Halterman, et al. *Pediatrics*, 107(6): 1381-6. 2001.

NAL Call Number: RJ1.P42

Abstract: Iron deficiency anemia in infants can cause developmental problems. However, the relationship between iron status and cognitive achievement in older children is less clear. The objective of the study was to investigate the relationship between iron deficiency and cognitive test scores among a nationally representative sample of school-aged children and adolescents using data collected in the National Health and Nutrition Examination Survey III 1988-1994. The National Health and Nutrition Examination Survey III provides cross-sectional data for children 6 to 16 years old and contains measures of iron status including transferrin saturation, free erythrocyte protoporphyrin, and serum ferritin. Children were considered iron-deficient if any 2 of these values were abnormal for age and gender, and standard hemoglobin values were used to detect anemia. Scores from standardized tests were compared for children with normal iron status, iron deficiency without anemia, and iron deficiency with anemia. Logistic regression was used to estimate the association of iron status and below average test scores, controlling for confounding factors. Among the 5398 children in the sample, 3% were iron-deficient. The prevalence of iron deficiency was highest among adolescent girls (8.7%). Average math scores were lower for children with iron deficiency with and without anemia, compared with children with normal iron status (86.4 and 87.4 vs 93.7). By logistic regression, children with iron deficiency had

greater than twice the risk of scoring below average in math than did children with normal iron status (odds ratio: 2.3; 95% confidence interval: 1.1-4.4). This elevated risk was present even for iron-deficient children without anemia (odds ratio: 2.4; 95% confidence interval: 1.1-5.2). We demonstrated lower standardized math scores among iron-deficient school-aged children and adolescents, including those with iron deficiency without anemia. Screening for iron deficiency without anemia may be warranted for children at risk.

Iron deficiency and the intellect. N. Gordon. *Brain and Development*, 25(1): 3-8. 2003.

Description: Children are especially liable to iron-deficiency anemia in developing countries, and in the inner cities of developed countries. Does the lack of iron cause impaired physical and mental development, and can this in certain circumstances be a permanent effect? One of the reasons that this is such a difficult question to answer is that there can be so many confounding factors, from other nutritional deficiencies, to helminthic infections and malaria in tropical countries. If there is a definite relationship, children in the first 2 years of life will be at particular risk during the major spurt of brain growth. Lack of iron can affect brain cells, myelin, or neurotransmitters, so there is certainly a theoretical basis for possible brain damage, or there could be an effect from lack of oxygen. Also anemic children are likely to feel ill and unwilling to co-operate with tests to assess for developmental defects. Many studies of the possible results of iron deficiency on the development of children have been carried out in various countries, and some of these from 1983 onwards are recorded. It is difficult to draw conclusions from these trials, partly due to the variability in their construction, but on balance the evidence suggests that treatment of iron deficiency is justifiable, whether this is associated with anemia or not. It is equally important to stress the importance of prevention, although more research is needed on the best method to use, which is both effective and affordable.

The effect of vitamin mineral supplementation on the intelligence of American schoolchildren: a randomized, double blind placebo controlled trial. S.J. Schoenthaler, et al. *Journal of Alternative and Complementary Medicine*, 6(1): 19-29. 2000.

Abstract: Many medical, nutrition, and education professionals have long suspected that poor diet impairs the academic performance of Western schoolchildren; academic performance often improves after improved diet. However, others have suggested that such academic gains may be due to psychologic effects rather than nutrition. To resolve this issue, two independent research teams conducted randomized trials in which children were given placebos or low dose vitamin mineral tablets designed to raise nutrient intake to the equivalent of a well balanced diet. Both teams reported significantly greater gains in nonverbal intelligence among the supplemented groups. The findings were important because of the apparent inadequacy of diet they revealed and the magnitude of the potential for increased intelligence. However, none of the ten subsequent replications, or the two original trials, were without limitations leaving this issue in controversy. The objective of this study was to determine if schoolchildren who consume low dose vitamin mineral tablets will have a significantly larger increase in nonverbal intelligence than children who consume placebos in a study that overcomes the primary criticisms directed at the previous 12 controlled trials. The study utilized a double blind, placebo controlled trial employing stratified randomization within each teacher's class based on pre-intervention nonverbal intelligence. Two "working class," primarily Hispanic, elementary schools in Phoenix, Arizona, participated in the study. Intervention included administration of daily vitamin mineral

supplementation at 50% of the U.S. daily recommended allowance (RDA) for 3 months versus placebo. Outcomes were calculated by post test nonverbal IQ, as measured by the Wechsler Intelligence Scale for Children Revised (WISC R), while controlling for pretest nonverbal IQ as a covariate. Findings consisted of four main results. First, a significant difference of 2.5 IQ points (95% CI: 1.85 3.15) was found between 125 children given active tablets and 120 children given placebo tablets ($p = 0.038$). Second, this finding is consistent with the mean 3.2 IQ point net gain found in the 12 similar but less rigorous studies. Third, a significantly higher proportion of children in the active group gained 15 or more IQ points when compared to the placebo group ($p < 0.01$). Fourth, although 81 matched pairs produced no difference at all in nonverbal IQ gain, the modest 2.5 IQ point net gain for the entire sample can be explained by the remaining 24 children who took active tablets, and had a 16 point higher net gain in IQ than the remaining 19 placebo controls. This study confirms that vitamin mineral supplementation modestly raised the nonverbal intelligence of some groups of Western schoolchildren by 2 to 3 points but not that of most Western schoolchildren, presumably because the majority were already adequately nourished. Because nonverbal intelligence is closely associated with academic performance, it follows that schools with children who consume substandard diets should find it difficult to produce academic performance equal to those schools with children who consume diets that come closer to providing the nutrients suggested in the U.S. RDA. The parents of schoolchildren whose academic performance is substandard would be well advised to seek a nutritionally oriented physician for assessment of their children's nutritional status as a possible etiology.

The evidence linking zinc deficiency with children's cognitive and motor functioning. M.M. Black. *Journal of Nutrition*, 133(5 Suppl 1): 1473S-6S. 2003.

NAL Call Number: 389.8 J82

Description: The role of zinc in children's cognitive and motor functioning is usually assessed by the response to supplementation in populations thought to be zinc deficient. A review of published zinc-supplementation trials that examined behavior and development identified one trial in fetuses, six trials in infants and toddlers and three trials in school-age children. The three studies that examined activity reported that zinc supplementation was associated with more activity. Of the five studies that examined motor development in infants and toddlers, one found improvements among very low-birth-weight infants, one found improvements in the quality of motor development and three found no impact. Of the four studies that examined mental development in infants and toddlers, three found no impact of zinc supplementation and one found that zinc-supplemented children had lower scores than control children. Among school-age children, one study found no impact of zinc supplementation on cognitive performance and two found a beneficial impact of neuropsychological processes, specifically reasoning. The evidence linking zinc deficiency to children's cognitive and motor functioning suggests a relationship among the most vulnerable children but lacks a clear consensus, highlighting the need for additional research into the timing of zinc deficiency and the co-occurrence with other micronutrient deficiencies.

The role of zinc in the growth and development of children. M.J. Salgueiro, et al. *Nutrition*, 18(6): 510-9. 2002.

NAL Call Number: QP141.A1N866

Description: This review concerns the importance of zinc in growth, development, and cognitive

function in children and the deleterious consequences of its deficiency on children's health. Possible strategies to overcome zinc deficiency and the results of some supplementation trials are discussed.

Zinc and cognitive development. S. Bhatnagar and S. Taneja. *British Journal of Nutrition*, 85(2): S139-S145. 2001.

NAL Call Number: 389.8-B773

Description: This article reviews the literature on zinc and cognition. Cognition is a field of thought processes by which an individual processes information through skills of perception, thinking, memory, learning and attention. Zinc deficiency may affect cognitive development by alterations in attention, activity, neuropsychological behavior and motor development. The exact mechanisms are not clear but it appears that zinc is essential for neurogenesis, neuronal migration, synaptogenesis and its deficiency could interfere with neurotransmission and subsequent neuropsychological behavior. Low maternal intakes of zinc during pregnancy and lactation were found to be associated with less focused attention in neonates and decreased motor functions at 6 months of age. Zinc supplementation resulted in better motor development and more playfulness in low birth weight infants and increased vigorous and functional activity in infants and toddlers. In older school-age children the data is controversial but there is some evidence of improved neuropsychological functions with zinc supplementation. Additional research is required to determine the exact biological mechanisms, the critical periods, the threshold of severity and the long-term effects of zinc deprivation on cognitive development.

B. Articles Dated Prior to 2000

Early iron deficiency anemia and later mental retardation. E. Pollitt. *American Journal of Clinical Nutrition*, 69(1): 4-5. 1999.

NAL Call Number: 389.8 J824

Description: Although the prevalence of iron deficiency anemia (IDA) has dropped significantly in the US during the last 3 decades (< 1% for children age 3-5), prevalence rates for some low-income children in some states are still much higher than those for the whole country (e.g. =30% of children tested in northern California counties were determined anemic). Thus, if early anemia is a cause of mild or moderate mental retardation, then the problem of IDA still demands consistent public health attention. This article looks at prior studies associating IDA and long-term intellectual deficits, including mild and moderate retardation.

Iron deficiency anemia and cognition among children. E. Pollitt, W.E. Watkins.

British Nutrition Foundation Nutrition Bulletin, 21(78): 129-136. 1996.

NAL Call Number: TX341.B75

Description: The particular hypothesis of concern from this guest lecture is that the reduced availability of cerebral iron in the early stages of development will result in cognitive alterations. Specifically, whether behavioral data supports the contention that iron deficiency during periods of rapid neuronal growth result in developmental alterations, and whether these alterations are irreversible as some animal data would suggest. It is the speaker's view that there is enough evidence to conclude that iron deficiency anemia causes mental and motor developmental delays and that the repletion of iron stores and the reversibility of the hematological derangement results in a successful developmental catch-up. In

support of this position, the author examines numerous studies which touch on the behavioral consequences in infants and toddlers of recent iron deficiency as well as the affects of iron deficiency during infancy on the performance of school-age children.

Randomized study of cognitive effects of iron supplementation in non-anemic iron-deficient adolescent girls. A.B. Bruner, et al. *The Lancet*, 348(9033): 992-996. 1996.

Abstract: Up to 25% of adolescent girls in the USA are iron deficient. This double-blind, placebo-controlled clinical trial assessed the effects of iron supplementation on cognitive function in adolescent girls with non-anemic iron deficiency. 716 girls who enrolled at four Baltimore high schools were screened for non-anemic iron deficiency (serum ferritin \leq 12 micrograms/L with normal hemoglobin). 98 (13.7%) girls had non-anemic iron deficiency of whom 81 were enrolled in the trial. Participants were randomly assigned oral ferrous sulphate (650 mg twice daily) or placebo for 8 weeks. The effect of iron treatment was assessed by questionnaires and hematological and cognitive tests, which were done before treatment started and repeated after the intervention. We used four tests of attention and memory to measure cognitive functioning. Intention-to-treat and per-protocol analyses were done. Of the 81 enrolled girls with non-anemic iron deficiency, 78 (96%) completed the study (39 in each group). Five girls (three control, two treatment) developed anemia during the intervention and were excluded from the analyses. Thus, 73 girls were included in the per-protocol analysis. Ethnic distribution, mean age, serum ferritin concentrations, hemoglobin concentrations, and cognitive test scores of the groups did not differ significantly at baseline. Post-intervention hematological measures of iron status were significantly improved in the treatment group (serum ferritin 27.3 vs 12.1 micrograms/L, $p < 0.001$). Regression analysis showed that girls who received iron performed better on a test of verbal learning and memory than girls in the control group ($p < 0.02$). In this urban population of non-anemic iron-deficient adolescent girls, iron supplementation improved verbal learning and memory.

Relationships among blood lead levels, iron deficiency, and cognitive development in two year old children. H.A. Ruff, et al. *Environmental Health Perspectives*, 104(2): 180-185. 1996.

NAL Call Number: RA565.A1E54

Abstract: The goals of this study were to explore the relationship of declining blood lead levels and cognitive development in 42 moderately lead poisoned children around 2 years of age and to investigate the potential interaction between iron and lead levels in the course of development. The cognitive functioning of children was assessed upon enrollment into a comprehensive intervention and 6 months later. The intervention consisted of chelation treatment, if appropriate, iron supplementation, if needed, and steps to eliminate the source of lead in the home environment. The children were referred because of blood lead levels between 25 and 55 $\mu\text{g/dl}$; they were also selected on the basis of age between 18 and 30 months. The outcome measures were the global score on a standardized test of cognitive development and subscale scores for perceptual motor and language functioning. Cognitive change over 6 months was related to an interaction between change in blood lead and initial iron status. Specifically, the change in standardized score (particularly change in perceptual motor performance) was strongly related to change in blood lead in children who were iron sufficient at the outset: there was an increase of 1.2 points for every 1 $\mu\text{g/dl}$ decrease in blood lead. There was no such relationship in iron deficient children. Secondary analyses suggested that 1) the change in cognitive functioning of iron deficient children was related to change in hemoglobin, and 2) the decline in blood lead was less in iron deficient

than in iron sufficient children. Thus, when iron is sufficient, changes in blood lead and changes in cognition are inversely related. When iron is deficient, other processes affect the outcome.

Zinc deficiency and child development. M.M. Black. *American Journal of Clinical Nutrition*, 68(2S): 464S-469S. 1998.

NAL Call Number: 389.8 J824

Description: Zinc is a trace metal that is present in the brain and contributes to its structure and function. Limited evidence from both animal and human studies suggests that zinc deficiency may lead to delays in cognitive development. Although the mechanisms linking zinc deficiency with cognitive development are unclear, it appears that zinc deficiency may lead to deficits in children's neuropsychologic functioning, activity, or motor development, and thus interfere with cognitive performance. In this article a model is presented that incorporates the influence of social context and the caregiving environment and suggests that the relation between zinc deficiency and cognitive development may vary by age in children and may be mediated by neuropsychologic functioning, activity, and motor development. Suggestions for further research are provided.

III. School Meal Programs, Learning and Behavior in the United States

A. Articles Dated 2000 - Present

Children's perceived benefits and barriers in relation to eating breakfast in schools with or without universal school breakfast. J. Reddan, K. Wahlstrom, M. Reicks. *Journal of Nutrition Education and Behavior*, 34: 47-52. January/February 2002.

NAL Call Number: TX341 .J6

Abstract: The purpose of this study was to identify and compare perceived benefits and barriers related to breakfast consumption and concerns about weight among children in schools with or without a Universal School Breakfast Program (USBP). The study's design involved a teacher-administered survey at the end of a 3-year pilot program. Fourth, fifth, and sixth grade students in six USBP pilot schools (n = 827) and four control schools (n = 615) were matched by geographic location and socioeconomic status of students. Response rates were > 70%. The study measured the perceptions of benefits and barriers related to breakfast consumption and weight-related concerns. Chi-square tests were used to assess statistical differences in categorical responses to survey items. The majority of students perceived that eating breakfast provides benefits of increased energy and ability to pay attention in school. Commonly held perceptions of barriers to eating breakfast were lack of time and not being hungry in the morning. Compared with children in non-USBP schools, those in the USBP schools were less likely to wish they were thinner, to go on a diet, or skip breakfast because it might make them fat and more likely to believe that eating breakfast will give them energy and help them pay attention. Based on the results of this study, nutrition educators may find it helpful to develop educational materials and programs based on the reciprocal determinism construct of Social Learning Theory to promote breakfast consumption. The focus should be on practical strategies to address barriers and encourage behavioral changes for both children and their parents.

Diet, breakfast, and academic performance in children. R.E. Kleinman, et al. *Annals of Nutrition Metabolism*, 46(1): 24-30. 2002.

NAL Call Number: RM214.N8 Abstract: The objective of this study is to determine whether nutrient intake and academic and psychosocial functioning improve after the start of a universal-free school breakfast program (USBP). Information was gathered from 97 inner city students prior to the start of a USBP and again after the program had been in place for 6 months. Students who had total energy intakes of <50% of the recommended daily allowance (RDA) and/or 2 or more micronutrients of <50% of RDA were considered to be at nutritional risk. Prior to the USBP, 33% of all study children were classified as being at nutritional risk. Children who were at nutritional risk had significantly poorer attendance, punctuality, and grades at school, more behavior problems, and were less likely to eat breakfast at school than children who were not at nutritional risk. Six months after the start of the free school breakfast programs, students who decreased their nutritional risk showed significantly greater: improvements in attendance and school breakfast participation, decreases in hunger, and improvements in math grades and behavior than children who did not decrease their nutritional risk. Participation in a school breakfast program enhanced daily nutrient intake and improvements in nutrient intake were associated with significant improvements in student academic performance and psychosocial functioning and decreases in hunger.

Evaluation of the School Breakfast Program Pilot Project: Findings from the First Year of Implementation. (Nutrition Assistance Program Report Series, No. CN-02-SBP). Food and Nutrition Service, Office of Analysis, Nutrition, and Evaluation, U.S. Department of Agriculture. Alexandria, VA: 2002. 506 pp. Available at: <http://www.fns.usda.gov/oane/MENU/Published/CNP/FILES/BreakfastPilotYr1.pdf>

NAL Call Number: aLB3479.U6-E92-2002

Description: Participation in the School Breakfast Program (SBP) by children from low-income households continues to be less than their participation in the National School Lunch Program (NSLP). There is concern that children might be coming to school without eating breakfast and still not be participating in the SBP for a variety of reasons, including a perceived stigma associating school breakfast participation with poverty. One approach to increasing participation in the SBP is to offer free breakfast to all students, regardless of their household's ability to pay for the meal. It is believed that a universal-free breakfast program would result in more children consuming a nutritious breakfast and beginning the school day ready to learn. This pilot experiment was based on an experimental design in which schools within each district were randomly assigned to implement the universal-free school breakfast (treatment schools) or to continue to operate the regular SBP (control schools). There are 79 treatment and 74 control schools in the pilot. In Spring 2001, about 4,300 students across the treatment and control schools were measured on dietary intake, cognitive function, and height and weight. Other data were also collected from parents and teachers. During the first year of implementation, the availability of universal-free school breakfast nearly doubled school breakfast participation (from 19 to 36 percent). Since most elementary school students in this study were consuming breakfast, the availability of free breakfast seems to have primarily shifted the source of breakfast from home to school. Given the low rate (less than 4 percent) of breakfast skipping, it is not surprising that the availability of universal-free school breakfast did not have a significant impact on measures of dietary

intake or school performance. Whether two additional years of exposure to the availability of universal-free school breakfast will have an impact on student outcomes will be determined after data collection and analyses for all three years are completed. A report of the findings on the impact of the availability of universal-free school breakfast on elementary school students over the three-year period will be available in 2004.

The Kids Cafe: a program to reduce child hunger. Y. Tapper-Gardzina, N. Cotugna. *Journal of Pediatric Health Care*, 17(1): 18-21. 2003.

Description: Hunger and food insecurity affect nearly 12 million children in the United States. Poverty is the foremost reason for hunger and food insecurity, but even the working poor sometimes have difficulty providing enough food for their household. Undernourished children may not present with severe clinical symptoms, but their ability to learn and psychosocial behavior can be affected. Feeding programs such as Kids Cafe can help decrease child hunger while improving learning and overall health. Kids Cafe's are operated by local food banks and sponsored by America's Second Harvest in partnership with ConAgra Foods, Inc. This article reviews the problem of child hunger and describes the Kids Cafe Program.

Nutrient contribution of breakfast, secular trends, and the role of ready to eat cereals: a review of data from the Bogalusa Heart Study. T.A. Nicklas, G.E. O'Neil, G.S. Berenson. *American Journal of Clinical Nutrition*, 67(4): 757S-763S. 1998.

NAL Call Number: 389.8 J824

Description: Breakfast consumption has been identified as an important factor in the nutritional well being of children. Several studies have indicated that omission of breakfast or consumption of an inadequate breakfast is a factor contributing to poor school performance and to dietary inadequacies that are rarely compensated for in other meals of the day. Differences have also been observed in the nutrient density of the breakfast meal, depending on whether it was consumed at school or at home. Ready to eat cereals make a significant contribution to the nutritional quality of diets of children and young adults. The Bogalusa Heart Study, which began 25 y ago, is an epidemiologic investigation of cardiovascular risk factors and environmental determinants in a biracial pediatric population. The purpose of this review is to present data from the Bogalusa Heart Study and other studies supporting the statements above.

Position of the American Dietetic Association: Child and adolescent food and nutrition programs. J. Stang, C.T. Bayerl. *Journal of the American Dietetic Association*, 103(7): 887-93. 2003.

NAL Call Number: 389.8 Am34

Web site: http://www.eatright.org/Public/GovernmentAffairs/92_17504.cfm

Description: This paper explains the American Dietetic Association's stance on Child and Adolescent nutrition programs. The Association's position is that all children and adolescents, regardless of age; gender; socioeconomic status; racial, ethnic, or linguistic diversity; or health status should have access to food and nutrition programs that ensure the availability of a safe and adequate food supply that promotes optimal physical, cognitive, and social growth and development. Appropriate food and nutrition programs include food assistance and meal programs, nutrition education initiatives, nutrition screening and assessment followed by appropriate nutrition intervention, and anticipatory guidance to promote

optimal nutrition status. Malnutrition has been linked to delayed physical, psychosocial, and cognitive development and is now recognized as a major contributor to the growing problem of overweight and obesity in the child and adolescent population.

B. Articles Dated Prior to 2000

An experimental study of the effects of energy intake at breakfast on the test performance of 10 year old children in school. D.P. Wyon, et al. *International Journal of Food Sciences and Nutrition*, 48 (1): 5-12. 1997.

NAL Call Number: TX341.H85

Abstract: In order to examine the effect of energy intake at breakfast on school performance the same morning, the parents of ten parallel school classes of 10 year old school children at five different schools were persuaded to alter their child's breakfast regimen at home over a period of 4 successive days. A total of 195 families were provided with standard breakfasts with either low or high energy content. Uneaten food was returned and weighed. Individual children were randomly assigned to breakfast alternative on any given day. The teachers who carried out the performance assessments at school were blind to treatment condition. Voluntary physical endurance and the performance of a creativity test were significantly better after a breakfast from which children derived over 20% of their recommended daily energy intake than after a breakfast from which they obtained less than 10% of recommended values. The error rate in an addition task was negatively correlated and the rate of working in a number checking task was positively correlated with individual energy intake from the low energy breakfast. Significantly fewer children reported feeling bad and self estimates of hunger sensation were lower during the morning at school after the high energy breakfast. Estimates of energy intake at breakfast based on 24 h dietary recall interviews with the children carried out by telephone at their homes showed good correlation with estimates based on returned food ($r = 0.89$). Energy intake at breakfast as estimated from returned food had no significant effect on energy intake at school lunch as estimated by dietary recall.

Breakfast and learning in children: symposium proceedings. (CNPP 9). Center for Nutrition Policy and Promotion, U.S. Department of Agriculture. April 1999. 109 pp. Available at: http://www.usda.gov/cnpp/Seminars/symposium_on_breakfast_and_learn.htm

NAL Call Number: aLB3479.U6 B74 1999

Description: Proceedings of a conference on children's health and nutrition that reviews the most recent scientific research on breakfast and school performance, and considers its implications for public policy.

Does breakfast make a difference in school? E. Pollitt. *Journal of American Dietetic Association*, 95 (10): 1134-9. 1995.

NAL Call Number: 389.8 Am34

Description: This article reviews selectively the literature on the effects of breakfast on cognition and school performance. Studies under review were conducted in both the United States and developing nations. The focus is on studies published in refereed journals after 1978 that tested those effects on well nourished and nutritionally at risk children. In at risk subjects (defined by clinical history and

anthropometry), a morning and overnight fast had adverse effects on cognition, particularly the speed of information retrieval in working memory. Contradictions in the data from different studies prevent definitive conclusions on whether well nourished children experience similar functional deficits. Nonetheless, available information suggests that brain function is sensitive to short term variations in the availability of nutrient supplies. Moreover, well conducted evaluations suggest that the availability of feeding programs in public schools throughout the academic year increases the probability that children will eat breakfast and improve their educational status.

Effect of breakfast timing on the cognitive functions of elementary school students. N. Vaisman, et al. *Archives of Pediatrics and Adolescent Medicine*, 150(10): 1089-92. 1996.

NAL Call Number: RJ1.A63

Abstract: The objective of this study was to examine the effect of breakfast timing on selected cognitive functions of elementary school students. A 2 week randomized control intervention trial in five elementary schools was conducted. The subjects comprised 569 children, 51% of them boys, aged 11 to 13 years; the children were in grades 5 through 6 (17 classes). The subjects lived in different areas and had different socioeconomic backgrounds. Each subject was tested twice, by 2 versions of the Rey Auditory Verbal Learning Test, 2 alternative forms of the logical memory subtest of the revised Wechsler Memory Scale, and 2 versions of the Benton Visual Retention Test. On the first test, before any nutritional intervention, the subjects were asked to complete a questionnaire about their food intake on the day of testing. Two thirds of the subjects received 200 ml of 3% fat milk and 30 g of sugared cornflakes for the next 14 days, and all the subjects were reexamined on the 15th day. The main outcome measure was the scoring on the different tests was compared with baseline scores. After 15 days, children who ate breakfast at school scored notably higher on most of the test modules than did children who ate breakfast at home and children who did not at breakfast. Results indicate that routinely eating breakfast 2 hours prior to being tested does not improve cognitive functions in 11 to 13 year old elementary school students, but food supplementation 30 minutes prior to taking a test notably improves scoring.

More than test scores: results of the Universal School Breakfast Pilot in Minnesota. K.L. Wahlstrom, M.S. Begalle. *Topics in Clinical Nutrition*, 15(1): 17-29. 1999.

NAL Call Number: RM214.T66

Description: The Minnesota State Legislature established a grant program to explore providing nutritious breakfast to elementary school students. The Universal Breakfast Pilot was subsequently extended for 2 School years. Six schools participated in the study, plus three control schools. Participation in Breakfast Pilot saw a greater increase over those of other breakfast programs. Benefits cited included better concentration, increased alertness and energy, and a decrease in stomach aches and headaches. Administrators saw a decrease in discipline problems, and benefits in social behavior, attendance, and a general increase in math and reading scores.

The relationship of school breakfast to psychosocial and academic functioning: cross sectional and longitudinal observations in an inner city school sample. J.M. Murphy, et al. *Archives of Pediatrics and Adolescent Medicine*, 152(9): 899-907. 1998.

NAL Call Number: RJ1.A63

Abstract: The objective was to determine if a relationship exists between participation in a school breakfast program and measures of psychosocial and academic functioning in school aged children. Information on participation in a school breakfast program, school record data, and in depth interviews with parents and children were collected in 1 public school in Philadelphia, PA, and 2 public schools in Baltimore, MD, prior to the implementation of a universally free (UF) breakfast program and again after the program had been in place for 4 months. One hundred thirty three low income students had complete data before and after the UF breakfast program on school breakfast participation and school recorded measures, and 85 of these students had complete psychosocial interview data before and after the UF breakfast program. Teacher ratings of behavior before and after the UF breakfast program were available for 76 of these students. Schoolwide data showed that prior to the UF breakfast program, 240 (15%) of the 1627 students in the 3 schools were eating a school supplied breakfast each day. Of the 133 students in the interview sample, 24 (18%) of the students ate a school supplied breakfast often, 26 (20%) ate a school supplied breakfast sometimes, and 83 (62%) ate a school supplied breakfast rarely or never. Prior to the UF breakfast program, students who ate a school supplied breakfast often or sometimes had significantly higher math scores and significantly lower scores on child , parent , and teacher reported symptom questionnaires than children who ate a school supplied breakfast rarely or never. At the end of the school term 4 months after the implementation of the UF breakfast program, school supplied breakfast participation had nearly doubled and 429 (27%) of the 1612 children in the 3 schools were participating in the school breakfast program each day. In the interview sample, almost half of the children had increased their participation. Students who increased their participation in the school breakfast program had significantly greater increases in their math grades and significantly greater decreases in the rates of school absence and tardiness than children whose participation remained the same or decreased. Child and teacher ratings of psychosocial problems also decreased to a significantly greater degree for children with increased participation in the school breakfast program. Both cross sectional and longitudinal data from this study provide strong evidence that higher rates of participation in school breakfast programs are associated in the short term with improved student functioning on a broad range of psychosocial and academic measures.

U.S. Department of Agriculture School Breakfast Program. E. Kennedy and C. Davis.

American Journal of Clinical Nutrition, 67(4): 798S-803S. 1998.

NAL Call Number: 389.8 J824

Description: This article reviews the history of the US Department of Agriculture School Breakfast Program (SBP) and provides a synthesis of factors influencing participation rates. Certain children are more likely to participate than others, such as those in lower grades and those from low income households, and African American, Hispanic, and male students. A few studies in the past 25 y have examined the effectiveness of the SBP in improving the diets and nutritional status of children. The overall pattern that emerges from these studies is that the SBP contributes to improved nutrient intake in program participants. Less attention has been devoted to assessing the effects of SBP on cognitive development. Some of the evidence reviewed here suggests that the SBP significantly improves school performance and reduces absenteeism and tardiness. Future directions for research and operation of the SBP are discussed in light of the changing dietary profile of American children.

IV. General Nutrition, Hunger, Learning and Behavior in Developing Nations

A. Articles dated 2000-present

An association between chronic undernutrition and educational test scores in Vietnamese children. A. Hall, et al. *European Journal of Clinical Nutrition*, 55(9): 801-4. 2001.

NAL Call Number: QP141.A1J68

Abstract: Using cross-sectional data collected during the baseline survey of a randomized trial, this study examined the association between results of educational tests and the anthropometric status of schoolchildren. The data originated from eighty-one primary schools in three districts of northern Vietnam and involved a total of 3055 schoolchildren enrolled in class 3 and born in 1990. After controlling for age, sex, district and school the results of test scores in both mathematics and Vietnamese were significantly negatively correlated with Z-scores of height-for-age ($P < 0.001$) and weight-for-age ($P < 0.001$), but not with weight-for-height ($P = 0.75$). A cross-sectional negative association was observed in Vietnamese primary school children between indicators of chronic undernutrition and tests of educational achievement.

Comparative school performance through better health and nutrition in Nsukka, Enugu, Nigeria.

R.O. Abidoye, D.I. Eze. *Nutrition Research*, 20(5): 609-620. 2000.

NAL Call Number: QP141.A1N88

Abstract: School academic performance was compared among primary school pupils of different nutritional and health status in Nsukka, Enugu State of Nigeria after a simple random sampling selection of participant pupils and retrospective assessment of their health and nutritional history dating back to their gestation periods. Mothers and guardians of the pupils supplied information on their health and nutritional history through a well structured self administered questionnaire. Two hundred and eighty five (73.1%) of the pupils selected, participated in the final studies. There was predominance of malnutrition among the pupils. Only 28.9% of the pupils were of normal weight for height (using Z scores on Nutritional Center for Health Statistics Values). 47.1% were mildly underweight, 20.1% were moderately underweight while 4.0% were severely underweight. Overall nutritional status (using weight for age Z scores) significantly affects school performance ($p < 0.05$). Only 26.0% of the pupils were of normal height for age, the rest were stunted. Complications for pregnancy was found to significantly affect later school performance ($p < 0.05$). Birth complications also significantly affected later school performance ($p < 0.05$). There was no significant association between duration of breast feeding and later school performance ($p > 0.05$). Of the social factors that influence health and nutrition, level of maternal education was found to have a significant effect on school performance of pupils ($p < 0.05$). Prenatal and postnatal conditions were found to affect school performance of children. Sustainable human development will therefore start with effective education of women which will produce a multiplier effect on succeeding generations. Investment in female education is an effective means of improving the quality of children, their school performance and their future performance and quality of life in adulthood.

Early childhood nutrition and academic achievement: a longitudinal analysis. P. Glewwe, H.G.

Jacoby, E.M. King. *Journal of Public Economics*, 81(2001):345-368. 2001.

NAL Call Number: HB9.J6

Abstract: This paper uses a longitudinal data set following a large sample of Filipino children from birth through the end of their primary education to examine the connection between nutrition and learning. Results indicated that better nourished children performed better in schools. The increased performance was attributed partly to the entrance of well-nourished children into school earlier, but, to a greater extent, because they had a greater learning productivity in school. A cost benefit analysis is provided.

Malnutrition at age 3 years and lower cognitive ability at age 11 years: independence from psychosocial adversity. J. Liu et al. *Archives of Pediatrics and Adolescent Medicine*, 157(6): 593-600. 2003.

NAL Call Number: RJ1.A63

Abstract: Early malnutrition is linked to poor cognition, but long-term effects have not been extensively examined and psychosocial confounds have not always been controlled. A prospective, longitudinal study of a birth cohort of 1559 children originally assessed at age 3 years for malnutrition (low hemoglobin level, angular stomatitis, kwashiorkor, and sparse, thin hair) were followed up to age 11 years. The sample consisted of a community of 1559 children (51.4% boys and 48.6% girls) born between September 1, 1969, and August 31, 1970, in 2 towns in the island of Mauritius, with 68.7% Indians and 25.7% Creoles (African origin). Verbal and spatial ability measured at ages 3 and 11 years and reading, scholastic ability, and neuropsychologic performance measured at age 11 years. Malnourished children had poorer cognition at both ages. Deficits were stable across time, applied to all sex and ethnic groups, and remained after controlling for multiple measures of psychosocial adversity. Children with 3 indicators of malnutrition had a 15.3-point deficit in IQ at age 11 years. Malnutrition at age 3 years is associated with poor cognition at age 11 years independent of psychosocial adversity. Promoting early childhood nutrition could enhance long-term cognitive development and school performance, especially in children with multiple nutritional deficits.

B. Articles dated Pre- 2000

Breakfast and cognition: an integrative summary. E. Pollitt, R. Mathews. *American Journal of Clinical Nutrition*, 67(4): 804S 813S. 1998.

NAL Call Number: 389.8 J824

Description: In this supplement, the papers presented at the International Symposium on Breakfast and Performance in Napa, CA in 1995 are summarized and integrated with data published since that time. The papers report on research conducted in the United States and abroad, conducted on adults and children. In particular, the focus is on issues of research design, measurements, mechanisms, potential effect modifiers (eg. age), and relevance for public policy. No definitive conclusions can be drawn from the existing data on either the long and short term benefits of breakfast on cognition and school learning or the mechanisms that mediate this relation. The pooled data suggest that omitting breakfast interferes with cognition and learning, an effect that is more pronounced in nutritionally at risk children than in well nourished children. At the very least, breakfast consumption improves school attendance and

enhances the quality of the students' diets.

Fasting and cognition in well and undernourished schoolchildren: a review of three experimental studies. E. Pollitt, S. Cueto, E.R. Jacoby. *American Journal of Clinical Nutrition*, 67(4): 779S-784S. 1998.

NAL Call Number: 389.8 J824

Description: This paper reviews three experiments on the effects of an overnight and morning fast on attention and memory processes among 9-11 year old children. Two of the experiments focused on middle class, well nourished boys and girls in the United States; the third involved boys from low income families with and without nutritional risk in Huaraz, Peru. All experiments used the same crossover design and followed similar experimental procedures to control the subjects' intakes and motor activity during the study period. The children were admitted to a research center on two different evenings, approximately 7 d apart. After arrival the children ate dinner, played table games or watched television, and went to bed. They were awakened at 0730 and, by design, were either served breakfast (approximately 2301 kJ) or not. At 1100 they took psychologic tests that assessed recall from working memory and competence in discriminating visual stimuli. At 1200 the children were discharged. The consequences of the overnight and morning fast, particularly among the children who were nutritionally at risk, included slower stimulus discrimination, increased errors, and slower memory recall. We propose that these alterations result from a state of metabolic stress in which homeostatic mechanisms work to maintain circulating glucose concentrations.

Malnutrition, brain development, learning, and behavior. N.S. Scrimshaw. *Nutrition Research*, 18 (2): 351-379. 1998.

NAL Call Number: QP141-A1N88

Description: Three widely prevalent nutritional deficiencies are recognized to have the potential for permanent adverse effects on learning and behavior: protein energy, iron, and iodine. Supplementation with adequate protein and calories during the first two years of life improves the cognitive performance of poorly nourished children, and the benefits may be even more robust years later when the children become adolescents and young adults. Iron deficiency is the most common global nutritional problem; among the earliest functions to be affected are those associated with the brain enzymes involved in cognition and behavior. The effects of iron deficiency during infancy appear to be irreversible. At older ages iron deficiency is intellectually and educationally disadvantageous independently of ethnicity and of physical and social environment. Even in areas where cases of cretinism due to iodine deficiency in the mother are few, the linear growth of the infant, its intellectual capacity, and certain other of its neurological functions are permanently compromised to varying degrees. In addition to these three most prevalent forms of deficiency, recent evidence suggests that cow's milk and infant formulas may lack sufficient omega 3 fatty acids for optimal development of the preterm infant and the neonate. Nutritional deficiencies are also potential contributors to impaired cognition in the elderly. Investments in education and community development would be more effective if the physical and cognitive capacity of underprivileged populations were not impaired by malnutrition.

Nutrition, anaemia, geohelminth infection and school achievement in rural Jamaican primary school children. S.E. Hutchinson, et al. *European Journal of Clinical Nutrition*, 51(11): 729-735. 1997.

NAL Call Number: QP141.A1J68

Abstract: The objective was to determine whether nutritional status, anemia and geohelminth infections were related to school achievement and attendance in Jamaican children. Design: A cross sectional study using a randomly selected sample. Subjects: Eight hundred children aged 9-13 y randomly selected from those enrolled in grade 5 in 16 primary schools in rural Jamaica. Results: The mean height for age of the children was 0.37 z score \pm 1.0 s.d. with 4.9% having heights for age < 2 s.d. of the NCHS references. Anemia (Hb < 11 g/dl) was present in 14.7% of the children, 38.3% were infected with *Trichuris trichiura* and 19.4% with *Ascaris lumbricoides*. Achievement levels on the Wide Range Achievement Test were low, with children performing at grade 3 level. In multilevel analyses, controlling for socioeconomic status, children with *Trichuris* infections had lower achievement levels than uninfected children in spelling, reading and arithmetic ($P < 0.05$). Children with *Ascaris* infections had lower scores in spelling and reading ($P < 0.05$) Height for age ($P < 0.01$) was positively associated with performance in arithmetic. *Ascaris* infection ($P < 0.001$) and anemia ($P < 0.01$) predicted poorer school attendance, Conclusion: Despite mild levels, under nutrition and geohelminth infections were associated with achievement, suggesting that efforts to increase school achievement levels in developing countries should include strategies to improve the health and nutritional status of children.

Nutrition, health, and child development: research advances and policy recommendations. Pan American Health Organization, Tropical Metabolism Research Unit of the University of the West Indies (Mona, Jamaica), and World Bank. Washington, D.C.: Pan American Health Organization, 1998

NAL Call Number: RJ131 .N88

ISBN: 9275115664

Abstract: Examines how and to what extent nutrition, health, and stimulation can affect children's cognitive and social developments and their ability to learn in school. Explores such topics as undernutrition, iron and iodine deficiencies, neonatal feeding, short term food deprivation, parasitic infections, and psychosocial deprivation.

Nutrition in early life and the fulfillment of intellectual potential. E. Pollitt. *Journal of Nutrition*, 125 (4S): 1111S-1118S. 1995.

NAL Call Number: 389.8 J82

Description: The effects of early supplementary feeding on cognition are investigated using data collected during two periods in four Guatemalan villages. The first was the Institute of Nutrition of Central America and Panama (INCAP) longitudinal study from 1969 to 1977 and the second was a cross sectional follow up of former participants carried out in 1988-1989. The principal objective of these studies was to assess the differential effect of two dietary supplements, Atole containing 163 kcal/682 kJ and 11.5 g protein per cup or 180 mL and Fresco containing 59 kcal/247 kJ and 0 g protein per cup, that were given to mothers, infants and young children. Performance was assessed on a battery of psychoeducational and information processing tests that were administered during adolescence. Consistent differences between groups were observed on psychoeducational tests. Subjects receiving Atole scored significantly higher on tests of knowledge, numeracy, reading and vocabulary than those given Fresco. Atole ingestion also was associated with faster reaction time in information processing tasks. In addition, there were significant interactions between type of dietary supplement and socioeconomic status (SES) of subjects. In Atole villages, there were no differences in performance

between subjects in the lowest and highest SES categories. On the other hand, performance in Fresco villages was best in the highest compared with the lowest SES group. After close scrutiny of alternative hypotheses, it is concluded that dietary changes produced by supplementation provide the strongest explanation for the test performance differences observed in the follow up between subjects exposed to Atole and those exposed to Fresco supplementation.

Results and implications of the INCAP follow up study. R. Martorell. *Journal of Nutrition*, 125(4S): 1127S 1138S. 1995.

NAL Call Number: 389.8 J82

Description: This article is a critical synthesis of 12 papers included in this supplement. The set deals with the short and long term effects of improving nutrition in Guatemalan villages characterized by deficient diets, high rates of infection and pronounced growth retardation in the first 3 y of life. The data reviewed come from two studies carried out over two decades: the Institute of Nutrition of Central America and Panama (INCAP) longitudinal study (1966 1977) and its follow up (1988 1989). The longitudinal study included a nutrition intervention that improved the energy and nutrient intakes of women and preschool children. Its effects included improved birthweights, reduced infant mortality rates and improved growth rates in children <3 y of age. Growth rates from 3 to 7 y of age, similar to those of well nourished children, were not affected by the intervention. The follow up study was conducted when the subjects were 11 27 y old. Among the long term effects found were greater stature and fat free mass, particularly in females, improved work capacity in males and enhanced intellectual performance in both genders. The nutrition intervention did not, on the other hand, accelerate maturation during adolescence, as measured by skeletal age or age at menarche. It is concluded that improved nutrition in early childhood has important long term effects in the adolescent and adult.

Severity and timing of stunting in the first two years of life affect performance on cognitive tests in late childhood. M.A. Mendez and L.S. Adair. *Journal of Nutrition*, 129(8): 1555 1562. 1999.

NAL Call Number: 389.8 J82

Abstract: Undernutrition in infancy and early childhood is thought to adversely affect cognitive development, although evidence of lasting effects is not well established. With the use of data from the Cebu Longitudinal Health and Nutrition Study, the relationship between stunting in the first 2 y of life and later cognitive development, focusing on the significance of severity, timing and persistence of early stunting was assessed. The sample included > 2000 Filipino children administered a cognitive ability test at ages 8 and 11 y. Stunting status was determined on the basis of anthropometric data collected prospectively between birth and age 2 y. Children stunted between birth and age 2 y had significantly lower test scores than non-stunted children, especially when stunting was severe. The shortfall in test scores among children stunted in the first 2 y was strongly related to reduced schooling, which was the result of a substantial delay in initial enrollment as well as higher absenteeism and repetition of school years among stunted children. Interactions between stunting and schooling were not significant, indicating that stunted and non-stunted children benefit similarly from additional schooling. After multivariate adjustment, severe stunting at age 2 y remained significantly associated with later deficits in cognitive ability. The timing of stunting was also related to test performance, largely because children stunted very early also tended to be severely stunted (chi(2) P = 0.000). Deficits in children's scores were smaller at age 11 y than at age 8 y, suggesting that adverse effects may decline over time. Results

emphasize the need to prevent early stunting and to provide adequate schooling to disadvantaged children.

Timing and vulnerability in research on malnutrition and cognition. E. Pollitt. *Nutrition Reviews*, 54 (2,pt.2): S49 S55. 1996.

NAL Call Number: 389.8 N953

Description: This paper focuses on the effects of intrauterine growth retardation type I (IUGR-1) and early supplementary feeding on cognition in late childhood and adolescence. The intent is to test whether the timing of these nutritional events partially determines the nature and scope of the adverse effects. This report also examines whether the timing of the measurement of a functional outcome (e.g., attention) determines the magnitude of the cognitive delay observed. Timing, therefore, is considered for both the predictor and the outcome. The data used are from two longitudinal studies, one in rural Guatemala and the other in Cali, Colombia. While the Guatemala study provided information on the effects of IUGR and supplementary feeding, the data from the Cali study are relevant solely to the issue of nutritional intervention.

C. Micronutrients, Learning and Behavior in Developing Nations

Articles dated 2000 -present

A developmental view of the effects of an energy and micronutrient supplement in undernourished children in Indonesia. Pollitt, E., Jahari, A., and Walka, H. *European Journal of Clinical Nutrition*, 54 (S2): S107 S113. 2000.

NAL Call Number: QP141.A1J68

Abstract: This paper presents the results of a structural equation model testing whether the longitudinal data of the Pangalengan subjects fit the theoretical model regarding the intellectual delay of undernourished children. Two cohorts of children were randomly assigned to three treatments: E = 1171 kJ + 12 mg iron; M = 12 mg iron + 209 kJ; S = 104 kJ. Supplementation was given for 6 months in six tea plantations in Indonesia. Subjects included a cohort of 2 month olds (n = 53) and an 18 month olds (n = 83) recruited from day care centers. Inclusion criteria were: no chronic disease; length for age = < 1 standard deviation (s.d.) and weight for length between 1 and 2 s.d. of the median of the reference of the World Health Organization. Twenty four hour dietary intakes were assessed using the weighted individual inventory technique. Body weight and length were obtained using standard procedures; motor development was assessed with the Bayley Scale and with a custom made scale for motor development leading to bipedal locomotion. Four hour observations were made of the child's interactions with the environment. Carrying a child in the arms and exploratory behavior were used as indicators of care-giving and exploration. All measurements were obtained every 2 months. Results indicated that the original model did not fit the data. The model was then modified with the inclusion of two new pathways: from activity and from motor development to mental development. Following these adjustments the model fit the data for each cohort and for both cohorts combined.

Effects of an energy and micronutrient supplement on mental development and behavior under

natural conditions in undernourished children in Indonesia. E. Pollitt, et al. *European Journal of Clinical Nutrition*, 54(S2): S80 S90. 2000.

NAL Call Number: QP141.A1J68

Abstract: This paper reports the effects of an energy and micronutrient supplement on mental development and on the social cognitive and emotionally regulatory behaviors of nutritionally at risk infants and toddlers in Pangalengan, Indonesia. Two cohorts of children were randomly assigned to three treatments: E = 1171 kJ + 12 mg iron; M = 12 mg iron + 209 kJ; S = 104 kJoule. Supplementation was given for 12 months at six tea plantations in Pangalengan, West Java. A 12 month old (N = 53) and an 18 month old (N = 83) cohort were recruited from day care centers. Twenty children who received S belonged to the 12 and 18 month old cohort. Inclusion criteria were: no chronic disease; length for age ≥ 1 standard deviation (s.d.) and weight for length between 1 and 2 s.d. of the median of the reference of the World Health Organization. Evaluations of intake were made at baseline and every 2 months thereafter. Motor development was assessed with the Bayley Scale and with a custom made scale to assess gross motor development leading to bipedal locomotion. Four hours of continuous observations were made of the child's interaction with the social and physical environment. In the 12 month old cohort, as compared with the M and S groups, the children who received the E supplement walked at an earlier age, had higher scores in the Bayley Scale and showed more mature social cognitive and emotional regulatory behaviors. Similar intergroup differences were observed in the 18 month old cohort in social cognition and regulation of emotions.

Effects of haemoglobin and serum ferritin on cognitive function in school children. R. Sungthong, L. Mo-suwan, and V. Chongsuvivatwong. *Asia Pacific Journal of Clinical Nutrition*, 11(2): 117-122. 2002.

NAL Call Number: QP141.A1 A74

Abstract: The association between iron deficiency anemia and cognitive function impairment has been widely reported in young children, but whether the impairment is a result of iron deficiency per se or a combination of iron deficiency and anemia, and how these conditions interact, is still questionable. Four hundred and twenty-seven school children from two schools in socioeconomically deprived communities were selected in southern Thailand. Iron status was determined by hemoglobin and serum ferritin concentrations. Cognitive function in this study was measured by IQ test and school performance, including Thai language and mathematics scores, using z-scores based on distributions within the same grade and school. Data on demography and socioeconomic status were collected by questionnaire answered by the parents. Linear regression models were used to investigate the effect of anemia and iron deficiency, reflected by hemoglobin and serum ferritin concentration, on cognitive function and school performance. We found that cognitive function increased with increased hemoglobin concentration in children with iron deficiency, but did not change with hemoglobin concentration in children with normal serum ferritin level. Children with iron deficiency anemia had consistently the poorest cognitive function (IQ, 74.6 points; Thai language score, 0.3 SD below average; and mathematics score, 0.5 SD below average). Children with non-anemic iron deficiency but with high hemoglobin levels had significantly high cognitive function (IQ, 86.5 points; Thai language score, 0.8 SD above average; and mathematics score, 1.1 SD above average). This study found a dose-response relationship between hemoglobin and cognitive function in children with iron deficiency, whereas no similar evidence was found in iron sufficient children.

D. Articles Dated Prior to 2000

A preliminary report: effects of zinc and micronutrient repletion on growth and neuropsychological function of urban Chinese children. J.G. Penland, et al. *Journal of the American College of Nutrition*, 16(3): 268-272. 1997.

NAL Call Number: RC620.A1J6

Abstract: Zinc is essential for growth and cognition of experimental animals. Past research found zinc repletion improved growth of stunted Chinese children. Therefore we measured effects of zinc repletion on growth and neuropsychological functions of children. It was a double blind randomized controlled treatment trial. The setting was elementary schools in low income districts of Chongqing, Qingdao and Shanghai. Three hundred seventy two 6 to 9 year old first graders were given one of the following interventions treatments: 20 mg zinc, 20 mg zinc with micronutrients, or micronutrients alone. The micronutrient mixture was based on guidelines of the US NAS/NRC. Treatments were assigned to classrooms of 40 or more children each, and administered by teachers 6 days per week for 10 weeks. Outcome was measured by changes in knee height and neuropsychological functions. Results indicated that zinc alone had the least effect on growth while zinc with micronutrients had the largest effect; micronutrients alone had an intermediate effect. Zinc containing treatments improved neuropsychological functions, but micronutrients alone had little effect. The findings confirm the essentiality of zinc for growth of children, and show, for the first time, the essentiality of zinc for neuropsychological functions of children. In addition, the need for repletion of other potentially limiting nutrients in studies examining the effects of specific nutrients on growth and neuropsychological functions was confirmed.

Effects of repletion with zinc and other micronutrients on neuropsychologic performance and growth of Chinese children. H.H. Sandstead, et al. *American Journal of Clinical Nutrition*, 68(2S): 470S-475S. 1998.

NAL Call Number: 389.8 J824

Description: The knowledge that zinc is essential for growth and neuropsychologic performance and a report of zinc responsive stunting in Chinese children prompted this project. This article summarizes findings from a 10 wk, double blind, controlled trial of zinc repletion in 740 urban, 6-9 y old first graders from low income families in Chongqing, Qingdao, and Shanghai, People's Republic of China. Treatments were 20 mg Zn alone (Z), 20 mg Zn with micronutrients (ZM), and micronutrients alone (M). The M mixture was based on National Research Council guidelines. Nutrients that might interfere with zinc retention were excluded or given in lower amounts. Main outcomes were changes in neuropsychologic performance and knee height. Hemoglobin, serum ferritin, plasma and hair zinc, and whole blood and hair lead were also measured. Anemia was not common, and serum ferritin concentrations were usually within the range of normal. Mean baseline plasma zinc concentrations were marginal in children from Chongqing and Qingdao and normal in children from Shanghai. After treatment with ZM or M plasma zinc increased. Hair zinc tended to decrease after all treatments. Mean baseline whole blood lead concentrations were slightly below the limit considered excessive for children by the US Centers for Disease Control and Prevention. Neuropsychologic performance and growth were

most improved after treatment with ZM. These findings were consistent with the presence of zinc and other micronutrient deficiencies.

V. School Meals Programs in Developing Nations

Cognitive and behavioural effects of a school breakfast. L.M. Richter, C. Rose, and R.D. Griesel. *South African Medical Journal*, 87(1S): 93 100. 1997.

Abstract: The cognitive and behavioral effects of a school breakfast were explored in a study of 55 children in Grade II and Standard 1 at a farm school outside Johannesburg, South Africa. A previous study had confirmed widespread undernutrition and micronutrient deficiencies among the children. For comparative purposes, 55 children at an inner city school, among whom no signs of undernutrition were found, were assessed in the same way. Three different types of measures of attention, distractibility, short term memory and activity level were used: psychometric testing of the children; teacher ratings of children's classroom behavior, and coded video recorded classroom behavior. A pre and post test design was employed to assess the effects of a school breakfast, continually in place in the experimental school for a period of 6 weeks. The results indicated significant change from pre to post test assessment among the experimental children in respect of the psychometric measures, teacher rated hyperactivity and video recorded classroom behavior. With regard to the latter measure, the children showed a decline in both the occurrence and duration of off task and out of seat behavior, and an increase in active participation in class and positive peer interaction. While the children in the comparison group also showed some changes from pre to post test, probably attributable to the effects of observation, familiarity with the test materials and developmental change, the changes were not generalized or consistent. The findings support the conclusion that a school breakfast programs had a beneficial effect on the cognitive and behavioral performance of socially disadvantaged, undernourished children in their first 2 years of school.

Does school breakfast benefit children's educational performance? L. Fernald, C.C. and Ani, S. Grantham McGregor. *Africa Health*, 19(6): 19 20. 1997.

Description: Primary school enrollment in Africa has doubled to reach 59% and secondary school enrolment has tripled to reach 38% in the last 3 decades, however failure rate in some countries is high. The poor school attainment levels are related to a poor nutritional status. The possible mechanisms whereby school performance could be affected by giving breakfast are discussed in this paper. One possible mechanism would be to provide breakfast at school, a probable result of which could be to increase the nutritional status of the child, increase school attendance and enrollment, decrease hunger and therefore produce metabolic changes which would improve the child's cognitive ability, resulting in an overall increase in school performance. Laboratory studies have shown that missing breakfast can detrimentally affect the cognitive function. Short and long term studies on providing breakfast at schools in Jamaica and Sweden have shown beneficial effects in learning and attendance. It is concluded that missing breakfast detrimentally affects the cognition of children, especially if they are undernourished. It is suggested that educational facility improvement programs need to be integrated with those aimed at improving children's health and nutrition.

Evaluation of school feeding programs: some Jamaican examples. S.M. Grantham McGregor, S. Chang, and S.P. Walker. *American Journal of Clinical Nutrition*, 67(4): 785S-789S. 1998.

NAL Call Number: 389.8 J824

Description: It is hypothesized that giving children a daily breakfast at school may improve their scholastic achievement through several mechanisms: increasing the time spent in school, improving certain cognitive functions and attention to tasks, and, perhaps indirectly, improving nutritional status. Two Jamaican studies showed that providing breakfast to students at school improved some cognitive functions, particularly in undernourished children. However, changes in classroom behavior varied depending on the quality of the school. Children in better organized schools concentrated on tasks for longer periods and made fewer undesirable movements, whereas in poorly organized schools the children's behavior deteriorated. Studies to date have provided insufficient evidence to determine whether children's long term scholastic achievement is improved by eating breakfast daily. Well designed, randomized, controlled, long term trials are essential for determining public policy on the implementation of school feeding programs.

Health and nutrition considerations in education planning. The cost and effectiveness of school-based interventions. J. Leslie, D.T. Jamison. *Food and Nutrition Bulletin*. 12(3): 204-214. 1990.

NAL Call Number: TX341.F622

Description: This paper discusses intervention packages and their costs, and then briefly overviews, from an economic perspective, the strength of the claim of health and nutrition interventions for school-age children on scarce resources. The authors conclude that, given what is known about the probable effect of health and nutrition interventions for learning and attendance, and given the relatively modest cost of a carefully signed, carefully targeted program, the implication for educational planners is clear: more investment in child health and nutrition will pay off well for education. Cost-benefit analyses suggest that appropriate health and nutrition interventions in the schools are likely to prove to be very high-yield investments.

Nutrition and education: a randomized trial of the effects of breakfast in rural primary school children. C.A. Powell, et al. *American Journal of Clinical Nutrition*, 68(4): 873-9. 1998.

NAL Call Number: 389.8 J824

Abstract: Hunger during school may prevent children in developing countries from benefiting from education. Although many countries have implemented school feeding programs, few programs have been rigorously evaluated. We conducted a randomized, controlled trial of giving breakfast to undernourished and adequately nourished children. The undernourished group comprised 407 children in grades 2-5 in 16 rural Jamaican schools (weights for age \leq 1 SD of the National Center for Health Statistics references) and the adequately nourished group comprised 407 children matched for school and class (weights for age $>$ 1 SD). Both groups were stratified by class and school, then randomly assigned to breakfast or control groups. After the initial measurements, breakfast was provided every school day for 1 school year. Children in the control group were given one quarter of an orange and the same amount of attention as children in the breakfast group. All children had their heights and weights measured and were given the Wide Range Achievement Test before and after the intervention. School attendance was taken from the schools' registers. Compared with the control group, height, weight, and attendance improved significantly in the breakfast group. Both groups made poor progress in Wide

Range Achievement Test scores. Younger children in the breakfast group improved in arithmetic. There was no effect of nutritional group on the response to breakfast. In conclusion, the provision of a school breakfast produced small benefits in children's nutritional status, school attendance, and achievement. Greater improvements may occur in more undernourished populations; however, the massive problem of poor achievement levels requires integrated programs including health and educational inputs as well as school meals.

School breakfast and cognition among nutritionally at risk children in the Peruvian Andes. E.

Pollitt, E. Jacoby, S. Cueto. *Nutrition Reviews*, 54(4pt.2): S22 S26. 1996.

NAL Call Number: 389.8 N953

Description: This paper describes and presents the main findings and conclusions of two studies conducted in Huaraz which were launched to assess the educational and nutritional impact of the School Breakfast Program. The first study tested the effects of breakfast on cognition among 54 elementary schoolchildren (ages 9-11) who were either well nourished or nutritionally at risk. The second study was a field evaluation of the feeding program in 10 rural schools on the periphery of Huaraz. Conclusions were drawn that the brain is sensitive to drops in the short term availability of nutrients, and that an overnight and morning fast produces a physiological state accompanied by changes in brain function, particularly working memory. This is particularly true among nutritionally at-risk children.

School feeding in Jamaica: a review of its evaluation. D.T. Simeon. *American Journal of Clinical Nutrition*, 67(4): 790S 794S. 1998.

NAL Call Number: 389.8 J824

Description: This paper reviews two studies that evaluated the school feeding program in Jamaica. The first examined 115 children aged 12 13 y who were enrolled in three classes in a poor, rural school. One class was served the standard school meal at 0900 whereas the other two classes served as controls. The outcome variables included school achievement, attendance, and weight gain. After one semester, the class receiving the meal showed improved arithmetic scores and school attendance compared with the control classes; however, they showed no weight gain. The academic improvement remained significant after school attendance was controlled for. It was therefore hypothesized that the gains in arithmetic resulted from the alleviation of hunger in the classroom. The other study, conducted in a metabolic ward, examined the effects of missing breakfast on cognitive function in 90 children aged 9 10 y and of differing nutritional status. Using a crossover design, the investigators tested each child on two mornings 1 wk apart, once after serving them breakfast and second without. Breakfast, consisting of the school program meal, was served at 0800. When severely malnourished, stunted, or wasted children received no breakfast, their performance in various cognitive tests deteriorated. These results indicate that alleviation of hunger was one of the mechanisms by which school feeding improved academic achievement in the previous study. Undernourished children are more likely to benefit from school feeding programs than are adequately nourished children.

When science and politics listen to each other: good prospects from a new school breakfast program in Peru. E.R. Jacoby, S. Cueto, E. Pollitt. *American Journal of Clinical Nutrition*, 67(4): 795S 797S. 1998.

NAL Call Number: 389.8 J824

Description: This article provides an overview of a school breakfast program implemented in 1993 in the Peruvian Andes. The program, designed by the Instituto de Investigacion Nutricional in Lima and supported by the government of Peru, constitutes a clear departure from previous school feeding programs, which were heavily politicized and poorly documented. From the program's inception, nutritionists, managers, and social scientists have collaborated to produce a sound nutritional design, efficient distribution mechanisms, and effective evaluation methods. During the program's first year, controlled evaluations conducted in several Andean regions documented improved dietary intake and a significant decline in the prevalence of anemia. An educational evaluation also found improved verbal skills, higher school attendance, and lower dropout rates among recipients of the school breakfast. The results have prompted the Peruvian government to continue supporting the program, thus setting a new standard for the effective management of social expenditure in the context of economic adjustment.

VI. Web Sites

Breakfast for Learning

Food Research & Action Center (FRAC)

<http://www.frac.org/pdf/breakfastforlearning.PDF>

Description: A brief review of the scientific research linking children's nutrition and academic performance.

Maryland Meals for Achievement Classroom Breakfast Program

Maryland State Department of Education

<http://www.msde.state.md.us/programs/foodandnutrition/MMACBPP.htm>

Description: Maryland Meals for Achievement (MMFA) is a classroom breakfast project that started in Fall 1998 in several Maryland elementary schools. Participating schools offer school breakfast in the classroom each morning, breakfast is free to all students, regardless of family income.

MetLife Survey of the American Teacher

Metropolitan Life

<http://www.metlife.com/Applications/Corporate/WPS/CDA/PageGenerator/0,1674,P2315,00.html>

Description: The MetLife 2002 Survey of the American Teacher finds that the lowest performing students are more likely than top students to come from low-income families, never eat breakfast, get less sleep and exercise less than higher-performing students. The survey is based on a nationally representative sample of 7th -12th grade public school teachers and students. Web site includes survey results from previous years.

School Breakfast Programs: Energizing the Classroom

Minnesota Department of Children, Families and Learning, March 1998

<http://www.nal.usda.gov/fnic/schoolmeals/States/energize.pdf>

Universal-Free School Breakfast Program Evaluation Design Project: Review of Literature on Breakfast and Learning, Final Report, December 1999

U.S. Department of Agriculture, Food and Nutrition Service

<http://www.fns.usda.gov/oane/menu/demoprojects/sbppilot/SBPlitreview.PDF>

This resource list was compiled by:

Jennifer K. Duvall, Dietetic Intern and
Elizabeth N. Hill, RD, Nutrition Information Specialist

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