GLOBAL LIVESTOCK CRSP

The Impact of Dietary Intervention on the Cognitive Development of Kenyan Schoolchildren

Shannon E. Whaley, Marian Sigman, Charlotte Neumann, Nimrod Bwibo, Donald Guthrie, Robert E. Weiss, Suzanne Murphy and Susan Alber
Child Nutrition Project

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Previous observational studies in developing countries have suggested that diet quality, particularly increased animal source food consumption, is positively associated with child cognitive development. This study reports the first findings of an experimental study in rural Kenya, designed to test the impact of three different diets on the cognitive development of school children. Twelve schools with 555 Standard 1 children were randomized to one of four feeding interventions: Meat, Milk, Energy, or Control (no feeding). Feeding continued for seven school terms (21 months), and cognitive tests were administered prior to the commencement of feeding and every other term of feeding. Hierarchical linear random effects models and associated methods were used to examine the effects of treatment group on changes in cognitive performance over time. Analyses revealed that children receiving supplemental food with meat significantly outperformed all other children on the Raven's Progressive Matrices. Children supplemented with meat and children supplemented with energy outperformed children in the control group on tests of arithmetic ability. There were no group differences on tests of verbal comprehension. Results suggest that supplementation with animal source food has positive effects on Kenyan children's cognitive performance. However, these effects are not equivalent across all domains of cognitive functioning, nor do all forms of animal source protein show the same beneficial effects.

Background

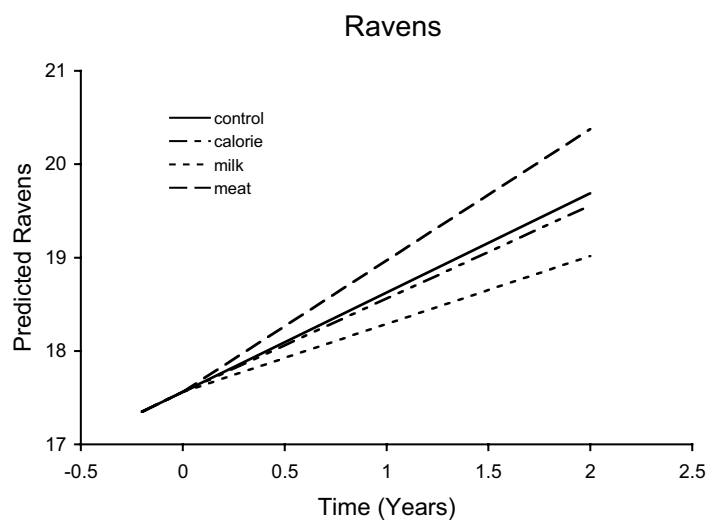
We have had the unique opportunity to study the impact of animal source protein on child cognitive development within the framework of the Global Livestock Collaborative Research Support Program (GL-CRSP) project titled "Role of Animal Source Foods to Improve Diet Quality and Growth and Cognitive Development in East African Children." Previous research in Embu, Kenya in the 1980's showed that children consumed over 75% of their energy intake from maize and beans, one percent from milk and less than one percent from meat (Murphy, Weinberg-Andersson, Neumann, Mulligan and Calloway, 1991). When investigating the developmental outcomes of these children, it was clear that children who consumed the least animal products performed least well on cognitive tests measuring verbal comprehension and perceptual abilities (Sigman, McDonald, Neumann & Bwibo, 1991; Sigman, Neumann, Baksh, Bwibo & McDonald, 1989a; Sigman et al., 1989b; Wachs et al., 1995).

This study reports the results of a controlled intervention study with school children in Embu, Kenya that was designed to test observational findings that animal source food plays a key role in the optimal cognitive development of children in this setting. The primary hypothesis addressed in this paper is that children receiving supplementation with animal source food will perform better on cognitive measures than children supplemented with an equivalent amount of calories from vegetable source foods. Whether supplementation with meat or milk leads to equivalent effects is an open question. Additionally, children supplemented with meat, milk, or energy are hypothesized to cognitively outperform a fourth group of children receiving no supplementation.

Measures and Data Analysis

This study is a four-condition design with three schools randomized to each condition, multiple children in each school, and five longitudinal measurements per child. Hierarchical linear random effects models and associated methods (Bryk and Raudenbush, 1992; Weiss and Lazaro, 1992) were used to examine the effects of treatment group on changes in cognitive performance over time. Longitudinal growth curves were calculated for all children on three cognitive tests across the five time points at which cognitive tests were administered. The cognitive battery included three tests used extensively in our previous work in Embu. The Raven's Colored Progressive Matrices (Raven, 1965) were used to assess performance-type abilities. The test measures the child's ability to organize perceptual detail and to reason by analogy and form comparisons. The Verbal Meaning Test was similar to the Peabody Picture Vocabulary Test (Dunn & Dunn,

Figure 1.



1981), but with pictures used previously in Eastern Africa. An Arithmetic test adapted from the WISC-R was used to assess basic knowledge skills.

Preliminary Results and Conclusions

There were significant group differences on the Raven's Progressive Matrices ($F(3,1509)=3.98$, $p=.01$). Post-hoc analyses revealed that children who received the supplement with meat showed significantly greater gains on the Raven's Progressive Matrices than all other groups (See Figure 1). Contrary to expectation, children in the energy and milk groups did not outperform children in the control group. As shown on Figure 2, the four groups of children did not differ in their performances on the Verbal Meaning test, ($F(3,1509)=.69$, $p>.10$). Group differences were evident on the Arithmetic test ($F(3,1509)=3.34$, $p=.019$). Children in the energy group and meat group both outperformed children in the control group. Contrary to expectation, children in the energy group outperformed those in the milk group (see Figure 3).

Results of this study suggest that supplementation with animal source food has positive effects on Kenyan children's cognitive performance. However, these effects are not equivalent across all domains of cognitive functioning, nor do all forms of animal source protein show the same beneficial effects. The most striking finding is the significant impact of supplementation with meat on performance on the Raven's Progressive Matrices. The Raven's is widely used as a culturally reduced test of fluid intelligence that taps into on-the-spot reasoning and problem-solving ability as opposed to accumulated factual knowledge. This finding suggests that increasing energy intake alone is not sufficient for improving cognitive performance, but the quality of the diet is important. In addition, meat and milk supplementation do not appear to be interchangeable - children supplemented with meat significantly outperformed children supplemented with milk in problem-solving ability.

These data suggest that meat, milk, and energy are not equivalent dietary supplements for children facing mild to moderate undernutrition. While these data do not allow for clear conclusions to be made about the mechanisms underlying the effects of supplementation on cognitive development, they suggest that meat provides a more bioavailable source of micronutrients than the other supplements. Meat has a higher energy density than the other supplements, and provides a combination of iron, zinc and heme protein that was not available in the other diets. Heme protein improves the bioavailability of iron and zinc from cereal and other plant sources (Pennington, 1997). Thus, it is possible that supplementation with meat contributed to measurable gains in micronutrient status, facilitating gains in specific domains of cognitive functioning.

Practical Implications

To our knowledge, this is among the first interventions to have supplemented children with three different diets across 7 school terms. Past studies suggested that animal source

Figure 2.

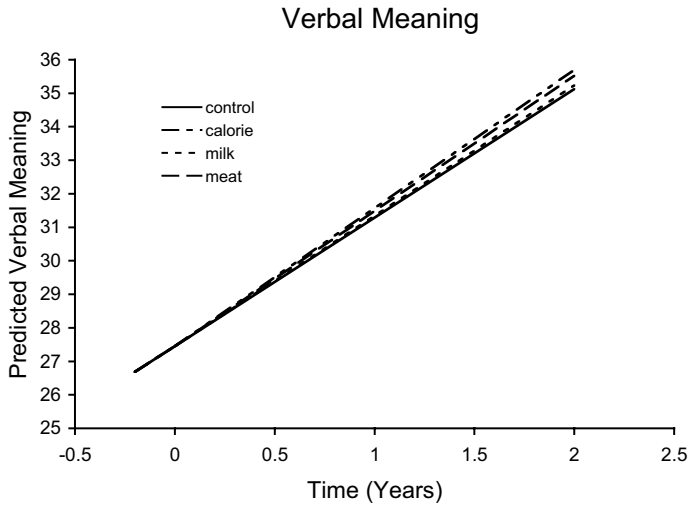
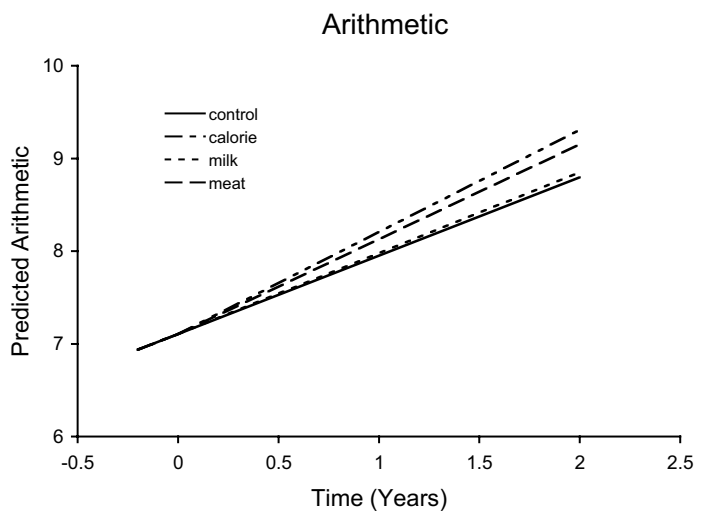


Figure 3.



foods were an important correlate of cognitive performance, but this is the first experimental demonstration of the efficacy of meat supplementation for child cognitive performance. Results of this study have significant practical implications for both families and policy surrounding the provision of food to undernourished children. Poor diet quantity and quality and micronutrient deficiencies are global problems, particularly among both rural and urban poor in developing countries and among the impoverished in industrialized nations (Scrimshaw, 1994). In developing countries where food security is low and children are mild to moderately undernourished, agricultural interventions to assist families in raising small animals such as rabbits and chickens for family consumption are likely to have significant positive impacts on children.

While this study highlights the importance of animal source foods for mild to moderately malnourished children in a developing country, these findings cannot be generalized to all children. The results suggest that the most effective food-based approaches to hunger prevention and optimal child development involve designing cost-effective and sustainable strategies to improve the micronutrient status of vulnerable groups. In countries like the United States, programs such as the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) and the school lunch program are designed to provide nutrient-rich foods to low-income children. Thus, it is likely that the micronutrient needs of undernourished children are being targeted in these programs. More importantly, these findings suggest that similar programs in developing countries that specifically incorporate animal source foods are likely to have the most beneficial impacts on the cognitive development of young children.

References

Bryk, A.S. and S.W. Raudenbush. 1992. *Hierarchical Linear Models : Applications and Data Analysis Methods.* Newbury Park: Sage Publications.

Dunn, L.M. and L.M. Dunn, eds. 1981. *Peabody Picture Vocabulary Test-Revised.* Circle Pines, Minnesota: American Guidance Service, Inc.

Murphy S. P., S.W. Weinberg-Andersson, C.G. Neumann, K. Mulligan and D.H. Calloway. 1991. "Development of research data bases: An example using foods consumed in rural Kenya." *Journal of Food Composition and Analysis,* 4, 2-17.

Pennington, J.A.T. 1997. *Bowes and Church's Food Values of Portions Commonly Used, 17th Edition.* Philadelphia: Lipincott Williams-Wilkins.

Scrimshaw N. 1994. "Consequences of hidden hunger." *Food and Nutrition Bulletin,* 15, 3-24.

Sigman, M., M. McDonald, C.G. Neumann and N. Bwibo. 1991. "Prediction of cognitive competence in Kenyan children from toddler nutrition, family characteristics, and abilities." *Journal of Child Psychology and Psychiatry and Allied Disciplines,* 32, 307-320.

Sigman, M., C. Neumann, M. Baksh, N. Bwibo and M. McDonald. 1989a. "Relationship between nutrition and development in Kenyan toddlers." *Journal of Pediatrics,* 115, 357-364.

Sigman, M., C. Neumann, A. Jansen and N. Bwibo. 1989b. "Cognitive abilities of Kenyan children in relation to nutrition, family characteristics, and education." *Child Development,* 60, 1463-1474.

Raven, J. C. 1965. *The Coloured Progressive Matrices Test.* London: Lewis.

Wachs, T. D., Z. Bishry, W. Moussa, F. Yunis, G. McCabe, G. Hamson, E. Sweifi, A. Kirkson, O. Galal, N. Jerome, and F. Shaheen. 1995. "Nutritional intake and context as predictors of cognition and adaptive behavior of Egyptian school-age children." *International Journal of Behavioral Development,* 18 (3), pp. 425-450.

Weiss, R. E. and C.G. Lazaro. 1992. "Residual Plots for Repeated Measures." *Statistics in Medicine,* 11, 115-124.

Further Reading

Allen, L. 1995. "Malnutrition and human function: A comparison of conclusions from the INCAP and Nutrition CRSP studies." *The Journal of Nutrition,* 125, 1119S-1126S.

Gorman, K. S. 1995. "Malnutrition and cognitive development: evidence from experimental/quasi-experimental studies among the mild-to-moderately malnourished." *The Journal of Nutrition,* 125, 2239S-2244S.

Grantham-McGregor, S. 1995. "A review of studies of the effect of severe malnutrition on mental development." *The Journal of Nutrition,* 85, 2233S-2238S.

Pollitt, E., K. Gorman, P. Engle, R. Martorell, and J. Rivera. 1993. "Early supplementary feeding and cognition: effects over two decades." *Monographs of the Society for Research in Child Development,* 58(7), 1-99.

Wachs, T. 1995. "Relation of mild-to-moderate malnutrition to human development: correlational studies." *The Journal of Nutrition,* 125, 2245S-2254S.

Wachs, T. D., Z. Bishry, W. Moussa, F. Yunis, G. McCabe, G. Hamson, E. Sweifi, A. Kirkson, O. Galal, N. Jerome, and F. Shaheen. 1995. "Nutritional intake and context as predictors of cognition and adaptive behavior of Egyptian school-age children." *International Journal of Behavioral Development,* 18 (3), pp. 425-450.

About the Authors: Shannon E. Whaley, Ph.D. is an Assistant Research Psychologist in the Departments of Psychology and Psychiatry at University of California, Los Angeles (UCLA). Her research interests center on the impact of risk environments on child development, with a particular focus on malnutrition, poverty and family psychopathology. Dr. Whaley can be contacted at swhaley@ucla.edu, or UCLA/NPI, Suite 68-237, 760 Westwood Plaza, Los Angeles, CA, 90024-1759.

Marian Sigman, Ph.D. is a Professor in the Department of Psychology and Psychiatry at UCLA. Charlotte Neumann, Ph.D, M.D., is a Professor in the Department of Public Health and Community Health Science at UCLA. Nimrod Bwibo, Ph.D.,M.D., is a Professor Emeritus of Pediatrics at the University of Nairobi, School of Medicine, Kenya. Donald Guthrie, Ph.D. is a Professor Emeritus in the Department of Psychiatry and Biostatistics at UCLA School of Medicine. Robert Weiss, Ph.D. is an Associate Professor in the Department of Public Health and Biostatistics at UCLA. Suzanne Murphy, Ph.D is a Nutrition Researcher, University of Hawaii Cancer Research Center. Susan Alber is a graduate student in the Department of Biostatistics at UCLA.

The GL-CRSP Child Nutrition Project (CNP) was established in 1997 and is built on a decade of research conducted by the Nutrition CRSP (USAID) in the 1980s. The Child Nutrition Project research addresses food-based approaches to micronutrient deficiencies, particularly of children with respect to both the quantity and quality of food intake. The study is centered on a controlled intervention feeding trial of school children in Embu, Kenya. The project is directed by Dr. Charlotte Neumann and Professor Nimrod Bwibo as Principal Investigators and Suzanne Murphy, Marion Sigman, Shannon Whaley, and Lindsay Allen as Co-Investigators. Email contact for Dr. C. Neumann is: cneumann@ucla.edu.

The Global Livestock CRSP is comprised of multidisciplinary, collaborative projects focused on human nutrition, economic growth, environment and policy related to animal agriculture and linked by a global theme of risk in a changing environment. The program is active in East Africa, Central Asia and Latin America.

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