Global Livestock CRSP

Supplementation with Beef or Milk Markedly Improves Vitamin B_{12} Status of Kenya Schoolers

Erin D. Reid, Charlotte G. Neumann, Jonathan H. Siekmann, Nimrod O. Bwibo, Suzanne P. Murphy, and Lindsay H. Allen
Child Nutrition Project

Research Brief 02-04-CNP May 2002

Based on food intake data collected on rural Kenyan children in Embu, Kenya in 1984-1987, a high prevalence of vitamin B_{12} deficiency was found. Similarly, in 1998 baseline values for an intervention study showed a high prevalence of vitamin B_{12} deficiency based on food intake and biochemical measures. In 1998, a two year controlled intervention with animal source foods was initiated in this same population to improve the micronutrient status of 6-9 year old rural Kenyan school children and test if animal source foods improve growth and cognitive function as well. Twelve schools were randomly assigned to three different but equicaloric food supplements. A local maize and bean stew (githeri) was used as the basic dish to which was added oil, beef, and milk respectively for each of the groups. Feedings were provided as a morning school snack 5 days/week. A control group received no school feeding. At baseline, 38% of children had severe and 30% of children had moderate vitamin B_{12} deficiency. In years 1 and 2 respectively, plasma B_{12} (ng/L) increased by 55 and 201 ng/L ($p< 0.0013 - 0.0001$) in the meat group; 84 and 126 ng/L ($p< 0.0013 - 0.0001$) in the milk group; and did not change appreciably in the added oil group or control groups. The increase of vitamin B_{12} concentration in the meat group was significantly greater than in the milk group at the end of year 2 ($p= 0.0017$). After 2 years of school feeding, severe deficiency in the meat group was nearly eliminated and greatly reduced in the milk group. Because vitamin B_{12} was alleviated by supplementation with animal products, the cause of B_{12} deficiency appears to be due mainly to low intake of animal source foods rather than to malabsorption due to infection.

Background

Vitamin B_{12} deficiency is being found increasingly in a number of low income countries (LICs) (Allen et al, 1995). Vitamin B_{12} deficiency in LICs may be caused by:

1. Low intake of animal source foods – Vitamin B_{12} concentration is high in meat and milk and virtually non-existent in plant-based foods, which are the predominant staples in LICs (Institute of Medicine, 1998).

2. Malabsorption – Bacterial overgrowth, particularly with Helicobacter pylori infection, which are more common in LICs and may impair B_{12} absorption from food (Allen et al, 1995).

Vitamin B_{12} plays a key role in nervous system development and brain function (Graham 1992), in red blood cell formation and other functions, and is almost exclusively furnished by animal source foods (Institute of Medicine, 1998). Food consumption data collected quantitatively in Embu, Kenya from 1984-1987 revealed that vitamin B_{12} and other micronutrients were deficient in the diet of school children (Murphy et al, 1995).

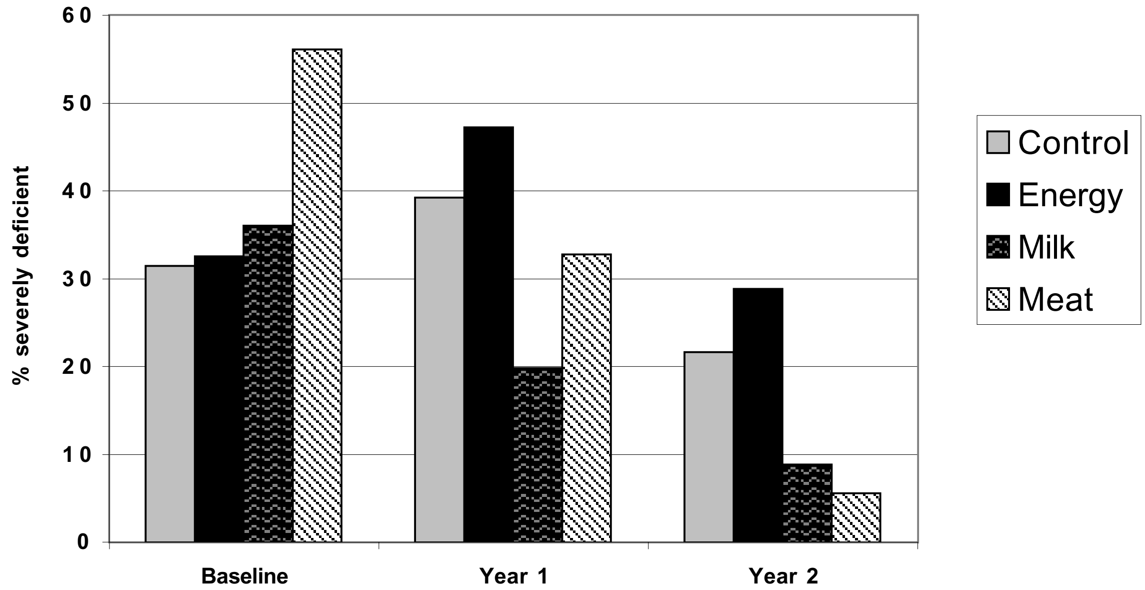
Intervention Study: Design and Method

In 1998 a controlled school feeding intervention study was initiated to determine whether animal products, fed daily in school, could reduce micronutrient malnutrition in these rural Kenyan children. The main objectives of the study are to assess whether there exists a casual link between meat and with milk and micronutrient status, cognitive development, and behavior, physical growth and health of schoolers. Reported here is the effect of the dietary interventions on vitamin B_{12} status. The hypothesis tested here is whether or not vitamin B_{12} deficiency can be improved by supplementation with animal source foods, both meat and milk.

Twelve Grade I classes in 12 different schools (555 children) were randomized at the school level to one of four groups:

1. Non-intervention Control
2. Githeri (a maize and bean stew) with added energy (oil)
3. Githeri with milk (200 mL of whole cow's milk for the first year, then 250 mL/d in the second year)
4. Githeri with beef (60 g for the first year, then 85 g/d for the second year)

Figure 1. Severe Vitamin B_{12} Deficiency at Baseline and 1 and 2 years after the intervention.



The milk provided 1/3 RDA for vitamin B_{12} and the beef doubled the RDA for 6-10 year old children. Meals were delivered to the school in the individual containers, 5 days per week for the three 3-month school terms per year. Leftovers were weighed and recorded. Over 99% of supplemental food was consumed when children were present. Mean school attendance was 84.5% and did not differ significantly between supplemented groups. Ages ranged from 5-14 years (mean ± SD, 7.4 ± 1.2y).

Blood samples were collected prior to the intervention (baseline) and at the end of one and two years. Plasma vitamin B_{12} was assessed in duplicate by radioimmunoassay. Severe B_{12} deficiency was defined as plasma vitamin B_{12} < 200 ng/L and marginal deficiency as 200-300 ng/L (Institute of Medicine 1998).

Changes in vitamin B_{12} concentrations were compared among the group using analysis of covariance, controlling for baseline values. Differences in the prevalence of vitamin B_{12} deficiency between groups were also determined. Some attrition was seen at follow-up blood drawings with children at the end of Year One and ~300 children at the end of Year Two. Results from children with evidence of infection as indicated by C-reactive protein and malaria were excluded, as infection lowers vitamin B_{12} concentration (Neumann et al, 2001).

Compared to the control group in years one and two respectively, plasma B_{12} increased by :

- 84 ng/L (p=0.0013) and 126 ng/L (p=0.0001) respectively in the milk group

- 55 ng/L (p=0.0145) and 201 ng/L (p=0.0001) respectively in the meat group (Figure 1)

These differences were highly significant compared to the Energy group and Control groups for both the Meat (p=0.0014, p< 0.0001) and Milk groups (p=0.0002, p< 0.0001) at the end of years one and two respectively. After Year Two of feeding, the increase in plasma vitamin B_{12} was significantly greater in the Meat group than in the Milk group (0.0017). Thus, compared to the Control and Energy groups, the prevalence of B_{12} deficiency decreased significantly in the Meat (p< 0.0001, p< 0.0001) and Milk (p= 0.0006, p<0.0001) groups after two years of intervention (Table 1) with a decrease of severe vitamin B_{12} deficiency to 8.8% in the milk group and 5.5% in the meat group (see table and figure).

Practical Implications

School feeding is sporadic, or non-existent in many rural areas of Africa and other poor countries (UNU-WFP, 2001). Where present, the feedings are usually devoid of or extremely low in animal source foods, which are a compact source of energy as well as multiple readily absorbed micronutrients. Moreover, meat and milk from a variety of species are the near exclusive sources of vitamin B_{12}. This nutrient plays a key role in nervous system development, brain function, and red blood cell formation. Several studies have implicated vitamin B_{12} deficiency in decreased cognitive function in affluent countries among children raised on strict vegetarian diets (Dagnelie et al, 1989) and more recently in poor countries (Allen et al, 1999). Modest amounts of milk and meat can greatly improve vitamin B_{12} status and eliminate severe vitamin B_{12} deficiency overall as diet greatly improves (Neumann, 2002).

References and Further Reading

Allen, L.H., J.G. Penland, E. Boy, Y. DeBaessa, and L.M. Rogers. 1999. "Cognitive and neuromotor performance of Guatemalan schoolers with deficient, marginal, and normal plasma vitamin B_{12}." *The FASEB Journal,* 13: A544 abstract.

Allen, L.H., J. L. Rosado, J.E. Casterline, H. Martinez, P. Lopez, E. Munoz, and A. K. Black. 1995. "Vitamin B-12 deficiency and malabsorption are highly prevalent in rural Mexican communities." *American Journal of Clinical Nutrition,* 62: 1013-9.

Dagnelie, P.C., and W.A. van Staveren. 1994. "Macrobiotic nutrition and child health: results of a population-based, mixed-longitudinal cohort study in The Netherlands." *American Journal of Clinical Nutrition,* 59:1187S-1196S.

Dagnelie, P.C., W.A. van Staveren, F.J. Vergrote, J. Burema, M.A. van't Hof, J.D. van Klaveren, and S.G. Hautvast. 1989. "Nutritional status of infants aged 4 to 18 months on macrobiotic diets and matched omnivorous control infants: a population-based mixed-longitudinal study. II. Growth and psychomotor development." *European Journal of Clinical Nutrition,* 43: 325-38.

Institute of Medicine (US). 1998. "Dietary reference intakes for Thiamin, Riboflavin, Niacin, Vitamin B-6, Folate, Vitamin B-12, Pantothenic Acid, Biotin, and Choline." A Report of the Standing Committee on the Scientific Evaluation of Dietary Reference Intakes and its Panel on Folate, Other B Vitamins and Choline. Subcommittee on Upper Reference Levels of Nutrients, Food and Nutrition Board, Institute of Medicine, National Academy Press, 306-356.

Graham, S.M., O.M. Arvela, and G.A. Wise. 1992. "Long-term neurologic consequences of nutritional vitamin B_{12} deficiency in infants." *Journal of Pediatrics,* 121: 710-4.

Murphy, S.P., D.H. Calloway, and G.H. Beaton. 1995. "School children have similar predicted prevalences of inadequate intakes as toddlers in village populations in Egypt, Kenya, and Mexico." *European Journal of Clinical Nutrition,* 49: 647-57.

Murphy, S.P, A.C. Gewa, M. Grillenberger, N.O. Bwibo, C.G. Neumann. 2001. "Changes in dietary quality for school children in Kenyan villages." *Annals of Nutrition and Metabolism*, 45 (Suppl 1): 24, Abstract 17, International Congress of Nutrition.

Table 1. Percent of Children with Mild and Severe Vitamin B_{12} Deficiency at Baseline and after One and Two Years of Intervention.

Timepoint	Group	Mild deficiency	Severe deficiency
Baseline	Control	28.4	31.4
	Energy	30.9	32.5
	Milk	33.3	36.0
	Meat	25.5	56.1
Year 1	Control	27.5	39.5
	Energy	27.6	47.2
	Milk	27.0	19.8
	Meat	23.6	32.7
Year 2	Control	35.1	21.6
	Energy	40.0	28.8
	Milk	26.3	8.8
	Meat	29.6	5.5

Neumann, C.G., L.H. Allen, and S.P. Murphy. 1996. "The role of animal source foods in improving diet quality and growth and development in young children." In *Latin America Regional Livestock Assessment Workshop Proceedings.* Davis, California: Small Ruminant CRSP (University of California--Davis), 191-205.

Neumann, C.G., N.O. Bwibo, and M. Sigman. 1992. *Diet quantity and quality: functional effects on rural Kenyan families.* Los Angeles, California: School of Public Health, University of California, Los Angeles, California.

Neumann, C.G., J. H. Siekmann, N.O. Bwibo, L. H. Allen, M. Grillenberger. 2001. "Impact of infection and malaria on micronutrient status in rural Kenyan children." *Annals of Nutrition Metabolism,* 45 (Suppl 1):16, Abstract 17, International Congress of Nutrition.

Neumann, C., D.M. Harris, and L. M. Rogers. 2002. "Contribution of animal source foods in improving diet quality and function in children in the developing world." *Nutrition Research,* 22, 193-220.

About the Authors: Erin D. Reid is a doctoral student at the University of California, Davis in the Department of Nutrition. She has a special interest in international nutrition, especially in low income countries.

Jonathan H. Siekmann, Ph.D., was a doctoral student on the project, carrying out the biochemical determinations. He received his degree from the University of California, Davis, Department of Nutrition. Charlotte Neumann, Ph.D., M.D., is a Professor in the Department of Public Health and Community Health Science at the University of California, Los Angeles. Nimrod Bwibo, Ph.D., M.D., is a Professor Emeritus of Pediatrics at the University of Nairobi, School of Medicine, Kenya. Suzanne P. Murphy, Ph.D., R.D., is a Nutrition Researcher at the Cancer Research Center of Hawaii, University of Hawaii, Honolulu. Lindsay H. Allen, Ph.D. is a Professor in the Department of Nutrition at the Univeristy of California, Davis.

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.

This publication was made possible through support provided in part by US Universities, host country institutions and the Office of Agriculture and Food Security, Global Bureau, United States Agency for International Development, under Grant No. PCE-G-00-98-00036-00 to University of California, Davis. The opinions expressed herein are those of the authors and do not necessarily reflect the views of USAID.

Design by Susan L. Johnson