GLOBAL LIVESTOCK CRSP

Anemia in Rural Kenyan Children: Role of Malaria, Infection and Poor Diet Quality and Meat Intake

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Anemia, defined as blood hemoglobin (Hb) level below 110 g/L, affects roughly half of Kenyan children. Anemia in children is associated with reduced physical activity, apathy, impaired cognitive function and increased infection. The causes of anemia can be multi-factorial. These include single or multiple nutritional deficiencies, malaria, intestinal parasites, systemic infections and genetic abnormalities. The nutrients of concern are found in abundance in meat, fish, or fowl. The impact of meat intake on anemia was studied in a randomized feeding intervention study of Kenyan primary school children and toddlers, aged 8-42 months. School children were fed on all school days with an isocaloric maize-based dish (githeri) supplemented with meat, milk, or additional oil for two years. Toddlers received isocaloric millet porridge with added meat, milk or oil for six to eight months. At baseline, anemia was found in 72% of toddlers and 49% of schoolers. Malaria was present in 13% of the toddlers and 32% of the schoolers, and was negatively correlated with Hb. In schoolers, Hb was significantly and positively associated with biochemical blood concentrations of iron, zinc, folate, vitamins B_{12} *and A. As for nutrient intakes in the schoolers, Hb showed weak but significant positive correlations with protein, folate, animal source vitamin A, and negatively with phytate and fiber. In toddlers, intakes of meat and heme iron were positively related to Hb. Although malaria is one of the main causes of anemia, little or no meat in the diet with its contribution of heme iron, high quality protein and vitamin* B_{12} *plays an important role. Both infection and poor diet quality must be addressed to conquer anemia.*

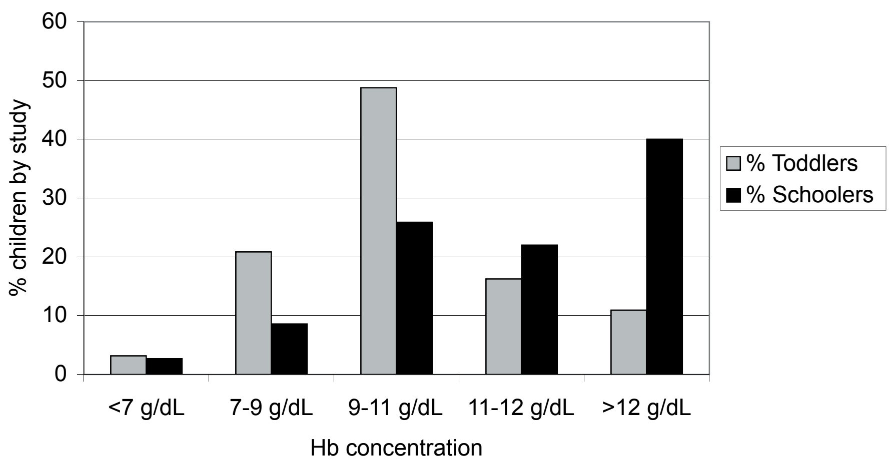
Background

Anemia, defined as blood hemoglobin (Hb) levels below 110 g/L, is widespread throughout developing countries and particularly in Africa. Anemia in children is associated with apathy, anorexia, decreased physical activity, work capacity, and impaired cognitive function and increased infection. Multiple and interacting factors cause anemia: poor diet quality with multiple nutritional deficiencies; intestinal and malaria parasites and systemic infection; and genetic red cell abnormalities and toxins. Observational research in Kenya in the 1980s demonstrated the beneficial effects of animal source food intakes, particularly meat, on growth, health, cognitive function, and physical activity in children. To establish a causative link with meat intake and the observed above outcomes, a randomized, controlled feeding intervention study in school children and toddlers in the same study area was carried out. Data were collected at baseline and longitudinally on the incidence of malaria and stool parasites, detailed morbidity, dietary intakes, blood biochemistry (in schoolers only), and hematologic studies. While macrocytic anemia results from folate or vitamin B_{12} deficiency, microcytic anemia results from iron deficiency and anemia also occurs with vitamin A deficiency. To better prevent and manage anemia, key factors contributing to Hg levels were identified.

Schools were randomized to four different groups: meat, milk, energy and control. Githeri was used as the vehicle for the added meat (Meat Group), added milk (Milk group), vegetarian stew with additional oil (Energy group) and a no-food control (Control group). School children were fed daily at school for 2 years, excluding holidays and school vacations. In the toddler study, toddlers attended feeding stations near their homes, which were randomized to three different isocaloric feeding groups consisting of millet porridge + ground beef (Meat group), porridge + milk (Milk group), and porridge + extra oil (Energy group). Toddlers were fed daily excluding holidays and weekends for six months.

Hemoglobin was measured with the Hemacue device, red blood smears examined, malaria detected by a Rapid Antigen Dip stick method, infection by C. reactive protein. Food intake and biochemical methods are described in a previous paper (Neumann et al 2003.) Statistical analysis included longitudinal bivariate analyses and multiple linear regression.

Figure 1: Distribution of Hb levels (%) in Study Children: Toddlers n=283, Schoolers n=510.



Major Findings

At baseline, 73% of toddlers and 38% of schoolers were anemic with severe anemia ($\leq$ 70 g/L) seen in 3.2% and 2.7% respectively (see Figure 1). At baseline, toddlers consumed an average of 0.74 µg of vitamin B_{12} and 0.78 mg of available iron, while schoolers consumed an average 0.4 µg vitamin B_{12} and 1.49 mg of available iron, all below the recommended dietary intakes (IOM, 1999; IOM 2001). As most toddlers were still breastfeeding, this may account for their greater vitamin B_{12} intakes compared with schoolers, as milk is a rich source of the vitamin.

A number of positive and statistically significant associations were found with Hb both in the schoolers and toddlers. In schoolers, increased intakes of protein, folate, and animal source (preformed) vitamin A consumption were positively associated with Hb at the end of the first and second years of the study. In toddlers, intakes of heme iron, vitamin B_{12}, and meat from household sources also showed positive and statistically significant associations with Hb levels. Also in schoolers, macrocytes were negatively associated with hemoglobin, indicating that macrocytic anemia from vitamin B_{12} and/or folate deficiencies contribute to the anemia. In toddlers, consumption of meat and milk, foods both rich in vitamin B_{12}, were negatively correlated with macrocytosis, giving support to the relationship between vitamin B_{12} deficiency and anemia.

As for biochemical micronutrient values in blood determined only in schoolers, there were positive and significant relationships between Hb and concentrations of iron and vitamin B_{12}. For every 1 µg/dL increase in serum vitamin B_{12} there was a 0.001 µg/dL increase in Hb. Copper and C-reactive protein (CRP) correlated negatively with Hb in both years of the study. Copper and CRP become elevated during infection and help to distinguish between infection-induced anemia and anemia resulting from nutrient deficiencies. Blood levels of iron, vitamin B_{12}, zinc, vitamin A, and folate were all positive predictors of Hb in the schoolers. As for intestinal parasites, in toddlers, ascaris was associated with anemia even after controlling for malaria. Mean Hb for toddlers with intestinal parasites was 91 g/L compared to 98 g/L for uninfected children. As expected, malaria had a dramatically negative effect on Hb. Toddlers positive for malaria had mean Hb 90 g/L as compared to those negative for malaria with mean Hb 103 g/L. In schoolers there was no significant effect of stool parasites on Hb, however, malaria infection was negatively associated with Hb.

Practical Implications

Anemia-control programs must engage a multi-strategy approach to effectively reduce childhood anemia in rural Kenya and similar areas globally. Malaria, intestinal parasites, and infection must be addressed in conjunction with dietary improvement to effectively reduce anemia prevalence. Decreasing malaria infections is a key element of a successful anemia-control program for children of all ages in malarious areas. Reducing intestinal parasites must also be targeted to reduce blood loss in these children, as well as enable them to benefit from improved diet quality. In addition to treatment for infection, clean water, and sanitation is important to reduce incidence of intestinal infection. Good water management, through integrated agriculture and health activities, can reduce mosquito populations and water-born diseases.

Increasing meat intake benefit Hb production, as it is a rich source of protein, iron and vitamin B_{12}. Iron in an absorbable form, vitamin B_{12} and protein are abundant in meat and vitamin A, and B_{12} in milk. Folate-rich foods are present in animal as well as plants. It appears that iron, vitamin B_{12}, folate and vitamin A deficiencies also are contributors to anemia in these children.

The reality is that animal source foods, such as meat and milk, are generally inaccessible due to prohibitive costs to resource-poor households. It is critical to identify ways in which small animal production can be integrated into local farming systems for household consumption. Generally increasing dietary diversity would improve intakes of the range of nutrients necessary to optimize nutritional status. In addition to increasing iron intakes through meat consumption, promoting increased fruit intakes rich in vitamin C, a promoter of non-heme iron absorption, could be an effective complementary action to improve nutritional status. Non-heme iron is found in foods such as dark green leafy vegetables, which are also good sources of folate, a nutrient necessary to prevent anemia.

Integrating livestock and agriculture, nutrition and health initiatives can reduce anemia and promote better health and cognitive outcomes for children in rural Kenya and elsewhere in developing countries, critical to social and economic development.

Further Reading and References

Allen, L.H., Rosado, J.L., Casterline, J.E., Martinez, H., Lopez, P., Munoz, E., & Black, A.K. 1995. "Vitamin B-12 deficiency and malabsorption are highly prevalent in rural Mexican communities. American Journal of Clinical Nutrition, 62 (5), 1013-1019.

Bwibo, N.O. & Neumann, C.G. "The need for animal source foods by Kenyan children." 2003. The Journal of Nutrition, 133 (11 Suppl 2), 3936S-3940S.

Haddad, E.H., Berk L.S., Kettering, J.D., Hubbard R.W., & Peters W.R. 1999. "Dietary intake and biochemical, hematologic, and immune status of vegans compared with nonvegetarians." American Journal of Clinical Nutrition, 70 (3 Suppl), 586S-593S.

Institute of Medicine Food and Nutrition Board. 1999. Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B6, Folate, Vitamin B12, Pantothenic Acid, Biotin, and Choline.

Institute of Medicine Food and Nutrition Board. 2001. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc.

Lozoff, B., Smith, J., Liberzon, T., et al. 2004. "Longitudinal analysis of cognitive and motor effects of iron deficiency in infancy." Pediatric Research. Abstract #128.

Murphy, S.P.& Allen, L.H. 2003. "Nutritional importance of animal source foods." The Journal of Nutrition, 133 (11 Suppl 2), 3932S-3935S.

Neumann, C.G. & Stephenson, L.S. 1991. "Other nutritionally related problems-interaction of nutrition and infection." In: Strickland, G.T., ed. Hunter's Tropical Medicine, 7th edition. Philadelphia, PA: WB Saunders, 947-950.

Siekmann, J.H., Allen, L.H., Bwibo, N.O., Demment, M.W., Murphy, S.P. & Neumann, C.G. 2003. "Kenyan schoolchildren have multiple micronutrient deficiencies, but increased plasma vitamin B-12 is the only detectable micronutrient response to meat or milk supplementation." The Journal of Nutrition, 133 (11 Suppl 2), 3972S-3980S.

Yip, R. 1994. "Iron deficiency: contemporary scientific issues and international programmatic approaches." The Journal of Nutrition, 124 (8 Suppl), 1479S-1490S.

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About the Project: The GL-CRSP Child Nutrition Project (CNP) was established in 1997 and was built on a decade of research conducted by the Nutrition CRSP (USAID) in the 1980s. CNP research addresses food-based approaches to micronutrient deficiencies, particularly of children, with respect to both the quantity and quality of food intake. The Child Nutrition Project was centered on a controlled intervention feeding trial of school children in Embu, Kenya. The Child Survival Study of toddlers was supported by funds from USAID as a follow-up to the study of school children. The project is directed by Dr. Charlotte Neumann, Dr. Suzanne Murphy, and Dr. Nimrod Bwibo as Principal Investigators and Dr. Marian Sigman, Dr. Lindsay Allen, and Dr. Shannon Whaley as Co-Investigators. Jonathan H. Siekmann, Ph.D., Ana Zubieta, Ph.D. former doctoral students and Erin Ried, a doctoral candidate, made significant contributions to the nutrition biochemical analyses. Email contact for Dr. C. Neumann is: cneumann@mednet.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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